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THE NAVAL USE OF THE DYNAMO MACHINE AND ELECTRIC LIGHT.

BY LIEUT. J. B. MURDOCK, U. S. N.

In submitting a paper to the Institute on so important a subject as the naval use of the electric light, my intention is merely to extract from the current scientific and technical literature of the day such information bearing on the subject as will enable one to reach a more exact comprehension of the field open for the electric light in modern naval warfare. The conclusions reached are often and necessarily different from those holding in cases of common utility, as naval requirements differ widely from those presenting themselves in ordinary life.

The electric light in a man-of-war is not to be regarded merely as an improvement or convenience, but strictly as a weapon of offense or defense. It is recognised as an invaluable defense against torpedo attacks, and owes its adoption into the navies of the world to the great development of torpedo warfare. The European powers long ago saw how utterly defenseless their huge ironclads would be against torpedo attack, and commenced experiments with the electric light.

In 1871 the Gramme machine was introduced in France, and very soon afterwards special modifications were made for military and naval service. It is unnecessary to refer to the experiments made in different countries testing the efficacy of the light, as they have uniformly resulted in its adoption. One navy after another has made practical tests, and in every case it has been shown conclusively that it would be simply impossible for a torpedo boat, in clear weather, to approach undetected a man-of-war aboard which the light was well used. Experiments at Newport show the same practical results, and, although nothing has yet been done towards the introduction of the light into our service, it will become necessary as soon as our ships are built with a view to meet the requirements of modern warfare. In nearly every navy in the world except that of the United States, the search light is established as a necessity, and is furnished to all large vessels.

Torpedo defense is, of course, the principal use of the light, but it would be of service in many other ways, as in chasing or engaging at night, keeping fleets or convoys together, in preventing collisions, in entering harbors, or in night signalling. Recently one of the ships of the British flying squadron shifted her foretopmast at night by the electric light of another of the squadron which lay near her, and the importance of the search light was conclusively shown by the British squadron at Alexandria. The light is very generally in use aboard cable ships, and notes are frequently seen stating that work was carried on all night which would otherwise have been impossible. Although the general utility of the light is undeniable, there remains a wide field for discussion of the details, which are still in the experimental stage.

The invention of the dynamo machine has given a new development to electricity, bringing it out of the laboratory into the sphere of every-day utility. At the Electrical Exhibition in Paris it was seen moving cars, boats and balloons, ploughing, boring, pumping, lifting, hammering, sawing, and driving a great variety of machines; conveying power from a stationary engine to make it available in a thousand ways at a distance. The starting-point of this new science of electricity is found in the discovery by Faraday, in 1831, of electromagnetic induction. The principle on which all magneto or dynamo machines are based is that if a coil of wire forming part of a closed circuit be moved in a magnetic field, a current of electricity is induced which can be utilized in any part of the circuit. We may know

nothing of the nature or cause of this induced current; but if by experiment its laws of increase, duration, direction or strength can be obtained, it is possible to utilize it. Whether electricity is matter, energy, or neither, is of but little consequence, if we know the laws governing its action. In this case of magneto-electric induction, the current is due to the motion of the coil. Without motion there is no current. Motion, however, involves the expenditure of energy, and if the experiments are made with exactness, it will be found that the energy of the current varies as the original energy expended in the motion, and is in some way caused by it. A discussion of the theories of electricity would be out of place here, but it is necessary to bear in mind that in all dynamo machines the development of current is obtained only by the expenditure of mechanical energy.

In the first machines constructed the field was caused by permanent magnets, and hence the name magneto-electric machines, and improvements were confined to placing the moving coils in the strongest possible field. Machines constructed on this principle were made for lighthouse use as early as 1850, but being bulky and not economical, never came into general use. The invention of Siemens' armature was a great improvement, and made possible the machines of Ladd and Wilde, in which the field was caused by electro-magnets. It was only a short step after this to suppress all permanent magnets and send the whole or a part of the current from the armature through the field coils, and the dynamo-electric machine was introduced to the world in 1867. These machines gave powerful currents, but heated so greatly that they could not be used for a long continuous run, and it was not until the introduction of the Gramme in 1871 that the system became a practical success.

Electromotive Force.

The action of the dynamo machine although apparently simple is difficult to formulate, calling for high mathematical analysis. The difficulty arises from the fact that the machine creates it own magnetic field, and every change of speed, resistance or temperature, not only affects the current, but also the field inducing the current. Without entering into a full mathematical discussion of the question, it is possible to examine it by a reference to the laws of induced currents, and thus obtain a practical knowledge of the conditions of construction and management that would best meet the requirements of any particular case.

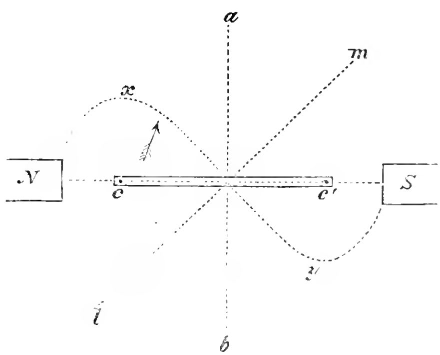
In general terms the Electromotive Force induced in a circuit is measured by the number of lines of force cut per second, or is the continued product of the intensity of the field, the velocity of the motion, the length of the conductor and the sine of the angle made with the lines of force.

1. The E. M. F. varies directly as the *intensity of the field.* MM. Mascart and Angot investigated this relation experimentally and published* the results obtained with Gramme permanent magnet machines, the intensity of the field of each being measured, and found that other things being equal, the E. M. F. for one turn of the armature is proportional to the strength of the field. Dynamo machines are in practical use because they cause a stronger field than can be obtained by permanent magnets. The field is caused in one of four ways. The first is by using a separate machine as exciter, the current from this passing through the field magnet coils of the generator. It has the great advantage of producing a field of constant intensity, and could be used advantageously when several machines are at work in one place, one then acting as exciter to all the others. When, however, only one machine is needed, as would frequently be the case, it is questionable whether there would not be greater economy with the ordinary dynamo. Second is the common dynamo, in which the whole current passes through the field coils, producing a very intense field, but having the great disadvantage that any increase of resistance in the external circuit would weaken the field and consequently the E. M. F. just when a high E. M. F. would be most necessary. In a machine intended for arc lighting this would not be a serious disadvantage. To obviate this defect Siemens introduced the third system, that of the shunt dynamo, in which the field coils are in a shunt of the main circuit. An increased external resistance in this type sends a more powerful current through the field coils, causing a more intense field and a higher E. M. F., but a sudden break in the external circuit might ruin the machine by sending the whole current through the field coils. To avoid this a resistance is automatically introduced. The fourth type has two or more coils on the armature, part of which send a current through the field coils, while the remainder are in the main circuit. This plan seems to possess many of the advantages of the other types while avoiding their defects. The details of winding the wire on the electro magnets are not of great importance, as in the

*Journal de Physique theorique et appliquée, Vol. VII, p. 363.

common dynamo enough turns are taken to insure the saturation of the magnets. The governing consideration is that the coils should have a certain resistance, and as this should generally be low the coils are made of large wire. The relations are more complex in shunt dynamos and would vary in different cases.*

The field is of course dependent on the position of the magnets, as well as on their strength. In nearly all machines pole pieces are used, so shaped as to almost encircle the armature, making the field larger and more uniform; and the armature revolving in close proximity to these pole pieces is at all times in a powerful field. M. Breguet † experimented on fields of working machines, deriving many important relations. His first step was to show that the presence of a conductor conveying a current in the field would cause a change from straight to S-shaped lines of force. This is theoretically evident, as every current causes lines of force concentrically encircling it; but M. Breguet pointed out that on the relative intensities of the current and magnet fields would depend the lead of the commutator more than upon the delay of demagnetization. His demonstration can be understood by the aid of a simple diagram. The figure represents a section through the armature of a machine, N and S being the opposing poles, and cc' the armature. If there were no current passing in the armature coil cc', the principal lines of force would pass from N to S nearly in straight lines. If, however,



a current passes while the armature is revolving in the direction of the arrow, the current would cause lines of force concentrically encircling the points c and c', and the combination of these with those of the field would give the line $NxyS$. The commutator brushes should press at the neutral points a and b, at right angles to NS, but when the line is distorted, the neutral points are at the extremities ml of a line perpendicular to $NxyS$ at its middle point, and the brushes must therefore be advanced to ml, *in the*

* See Siemens' paper on the Dynamo-Electric Current. (Van Nostrand.)

† Engineering, Feb. 20, 1880.

direction of the rotation. A similar investigation shows that when the machine is used as a motor the brushes should be *set back.* In experimenting on a Gramme machine at 1770 revolutions M. Breguet found that to avoid sparking the brushes had to be given 70° lead, 60° of which was due to the change of direction of the lines of force by the current passing.

It is well known that the presence of soft iron in the field produces a concentration of the lines of force, intensifying certain portions of the field, and resisting the curvature of the lines of force due to the current in the armature coils. The effect of the soft iron would be practically constant, while the current effect would depend on its strength. If the field due to the electro-magnets were weak, while a powerful current passed in the armature coil, there would be a great curvature of the lines, and it would be necessary to give the brushes a great lead. If, however, the currents were comparatively weak, a slight lead would be all that was necessary. The necessity of adjusting the brushes is forcibly shown in the following experiments by M. Marcel Deprez: *

Revs.	Total Res.	Current.	E. M. F.=RC.	
1000	1.595	19.60	31.26	Small Gramme machine. Electro magnets in separate circuit and kept at saturation. R and C measured, E calculated. Brushes fixed.
"	1.431	22.05	31.55	
"	1.248	24.00	29.95	
"	1.066	27.00	28.78	
"	.909	30.60	27.82	
"	.751	34.20	25.68	
"	.595	40.80	24.28	
"	.434	48.60	21.09	
"	.288	58.80	16.93	
"	.132	76.80	10.14	
"	.05	84.00	4.20	

The great decrease of resistance in circuit gave a more intense current in the armature, distorting the lines of force of the field and changing the neutral points of the commutator. The brushes being fixed, failed to take off the full strength of the induced currents. It is evident, therefore, that the position of the brushes is a matter of the highest practical importance, and that unfavorable results would be obtained from the best machines if proper care was not taken in this respect.

M. Breguet also showed that an iron cylinder in the field was not traversed by any lines of force. The obvious application is that there is no magnetic field on the inside of a Gramme armature, and that the internal half of the armature coils cuts no lines of force and conse-

* La Lumière électrique, June 17, 1882.

quently has no current induced. Half the armature coil therefore produces no good effect, while increasing the resistance. Many attempts have lately been made to produce a field inside the ring, and thus utilize the whole armature coil.

2. The E. M. F. in the induced circuit varies as the *velocity* of the conductor in the field. This fact admits of mathematical demonstration and has been experimentally proved. MM. Mascart and Angot have published * the record of an extended course of experiments with several Gramme machines with permanent magnets, from which they find the law to hold practically, throughout wide variations of velocity and circuit resistance. A slight weakening of the E. M. F., due to one turn of the armature, was observed at high speeds and with high resistances, but the known errors of measurement and of observation were thought sufficient to account for all discrepancies. In the dynamo machine, the simplicity of this law is modified by the interaction of the current and field, and it is questionable whether the exact relation has yet been determined. A definite strength of current is required to saturate the magnets, and until this point is attained the E. M. F. increases in a greater ratio than the number of turns, becoming thereafter sensibly constant. Some observations tend to show that the E. M. F. varies, at first, as the square of the number of revolutions. Another noticeable feature, in almost every table of experimental results, is, that although the ratio of the E. M. F. to the number of revolutions is practically constant, it varies slightly, rising to a maximum and then gradually decreasing at higher velocities. The following tables, showing results obtained by different observers with different machines, illustrate this fact:

M. Hagenbach, with an early Gramme machine. Internal Res. . . . 1.82 ohm. Ext. Res. . . . 1.94 "			Von M. Burstyn, with a C. Gramme. Total Res. 1.60			Dr. C. W. Siemens, with a Siemens machine as a common dynamo. Total Res. 1.64		
Revs.	E. M. F.	E. M. F. / No. of Revs.	Revs.	E. M. F.	E. M. F. / No. of Revs.	Revs.	E. M. F.	E. M. F. / No. of Revs.
539	8.2	.0152	410	54.9	.134	450	37.24	.0827
707	14.0	.0198	500	67.8	.136	500	44.84	.0897
905	18.3	.0202	615	83.9	.136	550	51.32	.0933
1178	22.2	.0188	700	93.9	.134	600	57.08	.0951
1416	26.0	.0184	750	99.5	.133	650	63.42	.0976
1584	28.5	.0180	810	107.9	.133	700	70.65	.1009
						750	76.32	.1176
						800	82.14	.1031

* Journal de Physique theorique et appliquée, Vol. VII, p. 79 and p. 363.

In experiments made with shunt dynamos this regular change is also indicated, and the ratio $\frac{\text{E. M. F.}}{\text{Revs.}}$ changes at different velocities. The following table of measurements, by Dr. C. W. Siemens, on a Siemens shunt dynamo, will illustrate :

Revs.	Tot. Res. in S. Units.	E. M. F.	$\frac{\text{E. M. F.}}{\text{Revs.}}$	Revs.	Tot. Res. in S. Units.	E. M. F.	$\frac{\text{E. M. F.}}{\text{Revs.}}$
450	1.12	28.85	.0641	850	1.12	64.51	.0759
500	"	33.16	.0663	800	"	59.73	.0746
550	"	38.56	.0701	750	"	55.07	.0734
600	"	43.97	.0733	700	"	51.15	.0731
650	"	48.77	.0750	650	"	45.63	.0702
700	"	52.87	.0755	600	"	41.27	.0688
750	"	56.14	.0748	550	"	37.79	.0687
800	"	61.69	.0771	500	"	32.73	.0655
850	"	64.51	.0757	450	"	28.33	.0629
900	"	68.31	.0759	...	...	...	...

The first column shows a maximum value of $\frac{\text{E. M. F}}{\text{Revs.}}$ at 800 revolutions, but this maximum is not shown in the second column when the machine was running at the same velocity. The increase in the value of the ratio is, however, well marked in its regularity.

This decrease of the value of the ratio, in the E. M. F. for one revolution, is manifested in almost every table of published results. It is impossible to imagine that the strength of the saturated magnets is diminished by an increase of current, and the decrease must therefore be sought in other causes, one of which may be that the armature core requires a perceptible time for changing its magnetism ; and as this is not allowed at high velocities, the magnetism of the core might induce an E. M. F. contrary to that due to the field magnets. Another cause is that already referred to, the necessity of adjusting the commutator brushes. In the earlier machines the brushes were fixed in their position, but they are now fitted so that they can be adjusted to take the current off at the proper time, and by still better adjustment the ratio might become more nearly constant.

If the armature cores require a definite time for changing their magnetism, it is evident that this would not be allowed at very high velocities ; and that, instead of losing their magnetism at the neutral points, they would carry it into the opposite field, resisting magnetization therein, and causing a definite loss of energy in moving them against the magnetic forces of repulsion. The energy thus applied,

instead of being converted into useful current, would be transformed into heat by the local currents induced, and this heating would increase the resistance of the armature and field coils, diminishing the current in the circuit. To avoid this difficulty, machines intended to be driven at high velocities usually have the armature core made of soft iron wires which lose their magnetism more quickly than would a bar of the same weight, and others not admitting of this construction have grooves, holes and fissures in the armature to break the continuity of its surface and prevent these local currents. Many machines adopt some way of cooling the armature by air blasts, or by placing the coils so that they fan the air in their rotation. These devices all tend to diminish the heating of the armature, but none overcome it, and it is evident that there is for every machine a velocity beyond which it cannot be run with economy.

3. The E. M. F. varies directly as the *length of the conductor*, but an increase of length brings with it increased resistance, so that there would be no gain of current if there were no external resistance. Generally, however, the external resistance is large compared with that of the coil, so that there is a gain by increasing the length of the coil. Here the necessity becomes apparent of adapting the machine to the work it has to do. The length of the coil would of course be measured between two divisions of the commutator, as in some machines the whole armature coil is in one piece, but connected at frequent intervals with the divisions of the commutator.

4. Since the E. M. F. varies as the sine of the angle made by the conductor with the lines of force, the maximum effect is obtained by cutting them at right angles, and the distribution of the lines in the field when working becomes a matter of the highest importance. The field of almost any machine at rest can be plotted by combining magnets to imitate it, and then sprinkling iron filings on paper covering the magnets. With the machine in motion, the distortion of the lines could be approximately determined by the principles brought out by M. Breguet, and in nearly all the efficient machines, particularly those of Gramme, Siemens, Brush and Edison, the conductor cuts a great number of lines at right angles.

5. If the armature coil revolves in the field instead of being carried on an armature which rotates, another consideration presents itself, viz. that in a coil *revolving* in a magnetic field, the E. M. F. varies as the *radius of the coil.* This consideration applies to armatures like those of Siemens, Maxim and Edison, but is complicated by the

fact that a large radius involves a large field, and it is difficult to make a large field intense throughout. In Edison's dynamo long cylindrical magnets are fitted into immense pole pieces completely encircling the armature which is 28 inches in diameter. The efficiency of this arrangement and these dimensions is shown by the fact that 350 revolutions give an E. M. F. of 110 volts.

Current and Work in Circuit.

In any circuit $C = \frac{E}{R}$, and at any instant this law would hold with dynamo machines. There are, however, some curious modifications possible. The dynamo machine renders mechanical work available as electric current, and supposing the work absorbed and the efficiency of the machine to be constant, the energy of the current would also be constant. This is represented by C^2R per second, or substituting by $\frac{E^2}{R}$. Since this is constant E varies as $\sqrt{R}$. Any change of resistance therefore in circuit affects the E. M. F., and *vice versa.* But $\frac{E^2}{R} = CE$ and $\therefore$ C varies as $\frac{1}{E}$, apparently in direct contradiction of Ohm's law. This peculiar relation, however, holds only where the current energy is the same, and this cannot be judged from the velocity of the machine, which may be constant, while absorbing different amounts of work.

Returning to Ohm's law, the current for any given E. M. F. would depend on the resistance in circuit. If this be great a high E. M. F. is necessary to produce a strong current, but if small a low E. M. F. will avail. The E. M. F., however, as has been seen, depends mainly on the way in which the machine is constructed, and it is therefore necessary to adapt the machine to the work expected from it, and one giving excellent results in one case would not answer under widely varying circumstances.

Another most important consideration is that of having a large proportion of the current energy available for the work required. When a steam engine is used to work an electric light by means of a dynamo machine, all the energy of the engine that is not utilized in the arc is practically wasted, and as this waste appears as heat in the machine or bearings it is directly prejudicial. Assuming that a definite percentage of the work of the engine would be lost in transmission, friction, etc., it is desirable to utilize as much of that which is converted

into current as is possible. The total work in circuit varies, other things being equal, as the total resistance, the work being measured in absolute units by C^2Rt, but the work in any one part of the circuit would be C^2rt, r being the resistance of that part. The percentage of work utilized therein would therefore be $\frac{C^2rt}{C^2Rt}$ or $\frac{r}{R}$, and this end would be gained by making r, necessarily less than R, as nearly equal to it as possible. It can be shown that the maximum work in the circuit is performed when the internal or machine resistance equals the external, but in that case half the total energy would take the form of heat in the machine. Sir William Thomson in a paper* read before the British Association, showed that the best results would be obtained by making the resistance of the electro-magnet coils somewhat less than that of the armature, and the external resistance large in proportion to the internal. The exact determination is as yet impossible, as it involves unknown relations. In the shunt dynamo the external resistance should be approximately a mean proportional between that of the armature and of the magnet coils, and the latter should be large in proportion to that of the armature.

Dr. Siemens examined experimentally the best relations in shunt dynamos, and the close accordance of his results with the theoretical deductions of Sir William Thomson is noticeable. The following shows the best observed external resistance in each of the tables accompanying his paper:

Table.	R = resist. of magnet coils.	R′ = resist. of armature.	Theoretical best external resist. $=\sqrt{RR'}$	Observed best external resist.	Efficiency
1	11.26	.234	1.62	2.0	70 pr. ct.
2	"	"	"	2.0	74 "
3	"	"	"	2.0	65 "
4	"	"	"	2.25	60 "
10	7.563	"	1.33	1.75	59 "
11	"	"	"	1.25	63 "
12	"	"	"	3.00	55 "
14	4.46	"	1.03	.90	53 "
15	"	"	"	1.00	56 "
16	11.26	.173	1.39	1.75	70 "
17	"	"	"	2.00	81 "
18	"	"	"	2.00	64 "
20	7.563	"	1.14	2.00	73 "
22	4.46	"	.88	2.0	52 "

In one or two cases in which the observed external resistance differs widely from the theoretical, there was only a slight difference of efficiency between the one given above and another nearer the theoretical value. The increased efficiency with the larger values of R is noticeable.

* Electrician, London, Oct. 1, 1881.

To obtain current from mechanical energy requires therefore a certain proportional internal resistance, but this resistance involves the waste of energy, which takes the form of heat in the coils, and is doubly prejudicial as heating increases the resistance, and increased resistance conversely causes additional heating. There is also reason to think that the resistance of the armature in motion is greater than when at rest on account of imperfect contact at the commutator. M. Lecoine in a communication to the French Academy of Sciences, detailed some experiments made on a cylinder of copper made to resemble the Gramme commutator, and found that the resistance of the circuit of which this formed part was 60 ohms at rest, increasing to 183 when the cylinder made 2000 turns per minute, and to 1567 at 5000 revolutions. The resistance was diminished by making the brushes touch more of the commutator divisions, and also by increasing the pressure holding the brushes against the commutator.

Apart from all theoretical considerations is the necessity of so arranging the parts of the machine as to change the mechanical work into available current. Making a machine with properly proportioned internal resistances would be of no avail if the magnet or armature coils were badly placed. The duty of a machine is often greatly impaired by an arrangement of parts which gives rise to local instead of available currents. This defect is somewhat analogous to the loss of energy in the cell by local action, and appears in the dynamo machine as heat. Heating is not in itself an indication of bad duty, as it would evidently be caused by a smaller external resistance than that properly due to the construction of the machine, but with a proper proportion of resistances excessive heating would be a proof of bad design.

From this preliminary examination the principal fact evident is the necessity of adapting a dynamo machine to the work required. As our subject is the naval use of the machine, an examination of the requirements of such service must next be considered.

Requirements of the Naval Service.

As a search light, the chief requirement is luminous intensity, all other considerations being comparatively subordinate. There seems to be a tendency in Europe to adopt a light of between 20,000 and 25,000 candles, the former being the minimum for use, the latter the maximum imposed by economical considerations. Every vessel provided with the light should have at least two, that no part of the

horizon may long be untraversed by the light beam, and that there may be a reserve at hand in case of accident. Two lights might be operated by one machine, and it has been conclusively shown that there is economy in the use of large dynamo machines over a number of smaller machines capable of doing the same work. The objection against one machine is the same as that against one light, that in case of accident no light could be obtained at all. Considering the peculiar circumstances of the case, that in time of war the machines might have to run all night for long intervals, and that only simple repairs could be made on shipboard, it would seem to be unwise to depend absolutely on one machine, and would be better to furnish two machines even if only one light were used. The requirement for power of light could therefore be summed up that the machine should be capable of producing one or two lights of 20,000 candles each.

Next in importance is the question of economy, rendered necessary from the fact that the dynamo machine produces electricity at the expense of coal, and no waste could be permitted. The amount of coal used would, however, depend mainly on the efficiency of the boiler and motor, and these should be tested apart from the machine. The fair measure of the economy of the machine itself is the ratio between the energy of the current in the external circuit and the power applied to turn its armature. The absolute economy of any system composed of boiler, motor, machine and lamp, would be the candle power in the arc per pound of combustible consumed.

Simplicity of construction and durability would be essentials entitled to some weight in making a selection, as the work of the machine might be great with but few facilities for repairs at hand in case of accident. The use of dynamos on shipboard would, of course, call for additional outfit, and ordinary work could be performed, but it would be necessary that the mechanical workmanship of the machine should be such as to insure easy and continuous working at high velocities, without injury to frame, shafts or bearings. This requirement is not always fulfilled, as was shown by the breaking of an armature several years ago aboard the Hartford.

Compactness would evidently be another point in favor of any machine. In most of our vessels cubic feet are none too plentiful, and it is desirable, therefore, that new machinery of any kind should be of as small bulk as possible. This would argue against the use of exciting machines.

As already seen, the controlling circumstance in the good working of any machine is that there should be a proper proportion of resist-

ances in the different parts of the circuit. All heating of field or armature coils involves waste of energy, and all heat not expended in the arc is practically lost. Heating must occur, however, and the problem would therefore be to make the resistance of the arc great in proportion to the rest of the circuit. But the best results have been given with an arc of small resistance, and hence for the good working of a *single powerful* light, small machine resistance is absolutely necessary.

Dynamo Machines.

Having thus ascertained the principal requirements to be fulfilled, we can examine the different machines as to their adaptability to the conditions of naval service.

The Gramme.—Although not the first dynamo machine, the Gramme came first into general use on the Continent, and is to-day in all probability more widely used in Europe than any other continuous current machine. Its advantages are many, as it gives a strong current of moderate E. M. F., has small and practically constant internal resistance, is simple in construction, easy in management, is durable and compact. Even at high velocities there is but little heating, and this principally in the magnet coils, and under proper adjustment the machine always possesses high efficiency. Some of the French machines for army use have two sets of coils on the armature, which could be coupled either in series or in multiple arc, thus allowing a certain amount of adjustment to adapt the machine to the resistance of the circuit. The new type Gramme has two armature coils, one in the main circuit, the other in that of the field coils, thus giving the advantage of a constant field with the simplicity of the common dynamo.

The disadvantages of the Gramme are not prominent. Some of the types required to be run at a very high speed, and although no evil effect is apparent, there can be but little doubt that this extreme velocity would impair the durability. Many theoretical defects have been pointed out in the machine, among which are the position of the commutator brushes, causing currents to flow through neutral wire, theoretically a loss of energy; the danger of short circuiting at the commutator, the brushes touching several divisions at once; and the loss due to the wire on the inside half of the armature coil cutting no lines of force, as was shown by M. Breguet. These are certainly defects, but it is questionable whether in attempts to improve them,

advantages have not been sacrificed. The most careful and thorough test of machines for military use yet made is probably that carried on by the Royal Engineers at Chatham in 1879–80.* The Gramme was tested against the Siemens and the Wilde, and on the report of the committee was adopted by the British War Office for defense of military posts. The data as to efficiency, etc., are given in the tables annexed, but some of the findings of the board can be noticed here. The D Gramme heated only 71° F. in a continuous run of six hours, with a current of 58.5 amperes, and the armature coils heated less than the field coils, so that the heating could be observed with the machine in motion. The absence of sparking at the commutator prevented wear of the brushes, and they could be easily adjusted. The simplicity and efficiency of the machine were marked, and it could be managed easily by persons having but little experience. The only objection given is that of the cost, £360. The C Gramme heated only 30° F. in a six hours run with 83.15 amperes and possessed the same advantages of simplicity, efficiency and absence of sparking, but required to be run at the high speed of 1200 revolutions. Two A Grammes coupled gave good efficiency, but much inconvenience and loss of time were caused by changes in the direction of the current.

Last winter tests were made at Portsmouth under the direction of Admiralty with the Gramme, Brush, and Siemens machines, but the results have not been published. The Gramme cannot work two powerful search lights, but is always used with one only. It is but little known in this country, although now sold by the Fuller Electrical Company of New York, and in the absence of all American experiments, the machines at Newport being of an old type, we can refer only to results obtained in Europe, and we there find the D Gramme in use aboard the first-class ironclads of almost every European power for working search lights, and the C in smaller vessels. Whatever may be the merits of other machines, the Gramme certainly has the advantage of possession of the field.

There have been many modifications of the Gramme type, some of which may possibly be improvements. The Bürgin machine has attained some popularity in England, has given excellent results in tests, and has advantages of cheapness, compactness and small internal resistance. In the Heinrichs machine a cross section of the armature coil is of a horse-shoe shape, thus reducing the idle part of the coil, that on the inside, from one-half to one quarter of the whole

* Revue industrielle, April 27, 1881. Engineering, XXXI, p. 492.

length. The Jürgenson and several others insert fixed electro-magnets inside the revolving armature, so as to cause a field inside the armature, and thus utilize the inner half of the coil.

Siemens.—This machine is extensively used in Europe, and has given very high efficiency in every well-conducted test to which it has been subjected. Dr. Siemens' own measurements are made under all possible circumstances, and are valuable not only as showing the efficiency of his machine, but in illustrating many important features of dynamos in general. Prof. Tyndall tested the Siemens machine for lighthouse use against the Holmes, the Alliance and an old type Gramme, and at his recommendation it was adopted for the Lizard lights. Tests at Newport have given the same favorable results as to efficiency, but in the Chatham experiments it was surpassed by the Gramme, both in efficiency and in power of light produced. The defects there found were heating, a rise of 110° F. in the armature, and of 85° in the field coils taking place in a six hours' trial, with a current of 55 amperes; sparking, resulting in rapid wear of the commutator and brushes; and greater liability to give unsatisfactory results or to get out of order, if the attendants had not had considerable experience in its use. Its chief advantage is its compactness; but one machine alone would not give sufficient power for a search light, and frequent delays resulted from coupling two together. The tests were made on the medium size machines, but later a large machine was tested. There was but little sparking at the commutators, but after a trial of about two hours the machine heated so that the magnet coils began to smoke, the current then being 63.48 amperes, and a rise of 150° F. was registered.

The Siemens machine is in extensive use in British merchant and cable steamers, and has been used in the Royal Navy with success. The chief peculiarity of this machine is in its armature, which is cylindrical, having the coils external to it and wound longitudinally, connected through the commutator in one continuous circuit. By placing the coils outside the iron of the armature there is no loss in half their circuit, as in the Gramme, and the only portions not cutting any lines of force are the radial connections at the ends of the cylinder. A larger proportion of each coil is therefore available for the production of current. The iron of the armature would also cause a concentration of the lines of force, until they became almost radial to the cylinder, and in this position they would be cut by the coils almost at right angles.

Brush.—The Brush machine is the one best known in this country, and its rapid adoption in all parts of the world indicates that it well fulfills the ordinary requirements of electric lighting, but the adaptability to work through a large external resistance would lead us, in accordance with general considerations already stated, to doubt its efficiency for working a single powerful light. The peculiarity of the Brush machine is that it gives a remarkably high E. M. F., designed to work through a large external resistance, and this being so, a comparatively high internal resistance is no disadvantage. For a single light the internal resistance would have to be greatly diminished, and it is unquestionable that this could be done and still have a sufficiently high E. M. F. to give a powerful light. It is unfair, therefore, to condemn the machine, as it is commonly seen in use, as not fulfilling the conditions of our problem. The Brush Electric Co. state they can make a No. 7 machine for one search light with an internal resistance of one-eighth of an ohm, and it is manifestly easier to construct a Brush machine of low resistance than to raise the E. M. F. of some other machines already having low resistance.

There are but few records of experiments with this machine for working a single light. Prof. Morton tested it for lighthouse use and obtained very good results, but the Newport experiments were less satisfactory, there being too high internal resistance, and the current not being adapted to the lamps. On another occasion, however, with the resistance of three lights in the external circuit, No. 5 machine, specially wound, a power of 11,000 candles was obtained from one lamp, carbons out of line. It is highly probable that a No. 7 machine could be constructed so as to give *two* lights of approximately 20,000 candles each, and if this could be done it would be a great advantage, as with two machines aboard both lights could still be worked if one machine were disabled.

The Brush is simple in its construction, works well, and is durable, but is somewhat heavier than others of about the same power. There are many advantages in the theory of the machine. The field is caused in a peculiar way, the electro-magnets having like poles opposed to each other, with the armature revolving between. By arranging magnets in this way, the lines of force will be seen to pass directly across from the poles to the armature, while the latter also has lines passing off from its extremities, or radially in the armature as constructed. This field is, of course, somewhat modified by the current when in operation, but as the current is comparatively weak the change would not be great, and each coil would cut lines

of force nearly at right angles on three of its four sides, inducing a high E. M. F. Another great advantage is that the coils are cut out near their neutral points, when not available for the production of useful current. A disadvantage of the machine is the projection of the coils from the armature, so that the rotation is opposed by the resistance of the air. This fanning is supposed to prevent heating, but must detract from the efficiency, and the heating could probably be prevented in some other way.

In summing up, it would seem to be unquestionable that the No. 7 Brush could be constructed to give one, if not two powerful search lights, but its efficiency might not be superior to that of the D Gramme. If the British Admiralty publish the records of the tests at Portsmouth this point may be determined.*

Weston.—The Weston machine is largely used both in this country and in England, but no exact tests of its efficiency seem to have been made until last August, when a ten-light machine was tested at the Torpedo Station, with the results given in the appended tables. Its gross efficiency is seen to be high, 83 per cent. working with eight lights in circuit, while the candles per H. P. applied average higher than in any other machine. Prof. Morton's experiments also gave it a high standing, his measurement of 1800 candles with hand lamp and 1663 with Maxim per H. P. applied, being on an equality with the best performance of other machines. The Weston machine is compact and has given satisfaction in its working. The armature coils are wound on a framework formed of a number of disks keyed to a shaft, securing ventilation and cooling of the coils by a draught of air. The internal resistance is comparatively low, and could probably be reduced, and it is highly probable that the Weston could be modified to work two powerful lights in the same circuit, while retaining its high efficiency.

Maxim.—This machine is also of American origin, and has in careful tests given good results and high efficiency. Some types have two sets of coils on the armature which can be coupled either in series or in parallel arc. It is generally used for incandescent lighting, having its field coils in the circuit of an exciting machine, but has shown high efficiency for arc lighting, and has moreover been used to a certain extent on shipboard, a projecting lamp having been made long ago for this purpose. The armature is cylindrical and wound longitudinally as in the Siemens, but the commutator connections are different.

* In September the Admiralty ordered eight *Gramme* machines for search lights.

Edison.—Much interest has been displayed in Edison's dynamo, which is in many respects different from any preceding it. It is designed as a part of his system, but also seems well adapted to use with a single powerful light. It possesses very small internal resistance, and the tables show its wonderful efficiency. A comparison of Mr. Howell's measurements on a small machine, with those recorded of the C Gramme at Chatham, would seem to indicate that the Edison would work a search light most effectively, while its efficiency is higher than that of the Gramme. For convenience, the figures are given here.

	H. P. applied.	Revs.	C.	E. M. F.	Tot. Res.	Res. Arc.	Candles.	Efficiency $= \frac{\text{H. P. appl.}}{\text{H.P. current.}}$
C Gramme	9.52	1200	81.22	69.9	.86	.627	19,500	80 pr. ct.
						Ext. Res.		$= \frac{\text{H. P. appl.}}{\text{H.P. in external circuit.}}$
Edison,	7.86	1200(app.)	88.97	61.93	.696	.68	?	90.2 pr. ct.

The differences are decidedly in favor of the Edison machine, but no experiments have ever been made with it for arc lighting.

Wallace-Farmer.—Although possessing some theoretical advantages this machine has failed to give satisfactory results in any trial. Excessive heating occurs, and indicates bad design and the production of an undue amount of local currents. This machine was tried aboard the Hartford several years ago, when it failed to give good practical results, and a more serious objection to its use was the breaking of the armature by centrifugal force. The armature was of cast iron, and was deeply furrowed to prevent the induction of local currents and to diminish the weight, but was thereby weakened.

Wilde.—The Wilde machine was used for many years in the Royal Navy for the production of a search light, but has been supplanted by the Gramme, especially since the Chatham tests.

De Meritens.—A step has apparently been taken backward in the last year by the return to magneto-electric machines. M. de Meritens has adopted permanent magnets on account of the constant field produced, and his machines have been adopted by the French government for use in over forty lighthouses, but the conditions holding here are very different from those in existence in naval use. This lighthouse machine has five revolving rings carrying eighty bobbins in four multiple arcs, and he claims with 1000 revolutions to produce a light of 15,000 candles. The peculiar advantages fitting this machine for lighthouse service are its constancy of action, and its

alternating currents which admit of easy focusing and dispersion of the light in a horizontal plane. M. de Meritens also makes continuous current machines.

Alternating Current Machines.—Different from those yet considered are the alternate current dynamos of Gramme, Siemens, Lontin and others which owe their existence principally to the invention of the Jablochkoff candle. Both they and the candle are practically unknown in this country, and unless they should be adopted for incandescent lighting, they may remain confined to Europe. As an illustration of the economy (?) of the system may be cited the lighting of the port of Havre by thirty-three Jablochkoff candles, each of 700 candle power, supplied by *four* machines, two exciters and two alternate current Grammes, the power being furnished by two 35 H. P. engines. Compare this with the lighting of forty 2000 candle lights by *one* Brush machine absorbing 40 H. P., as may be seen in almost every large city in the United States, and the criticism that the alternate current machines are wasteful of energy would seem to be substantiated. The advantage of these machines for arc lighting is that with alternate currents the carbons burn equally, and the light is given off in a horizontal plane; the disadvantages are that the arc is extinguished at every reversal of the current, and relighted, and this extremely rapid reversal of currents induces extra currents of high E. M. F., which are more dangerous than those in continuous current circuits. The more rapid the reversal the higher the E. M. F. of this induced current, and the greater the danger of touching the wires. On this account some authorities have laid down the law that alternate currents should not be used on shipboard.

For convenience of comparison the following data of the most prominent dynamos are presented together. In selecting them care has been taken to choose measurements made by experts, rejecting any that are at all in doubt. The measurements made on the Bürgin and Crompton-Bürgin machines are copied from *Engineering* and the *Electrician* and are probably reliable. In order to secure uniformity many data have had to be calculated in part, as the original measurements were in many cases tabulated in very different methods from that adopted here. H. P. *applied* is given whenever possible, as the friction of the generator militates against its efficiency, and should not be deducted. In many cases, however, H. P. *absorbed* is given, the other not being obtainable, and is so stated in the tables.

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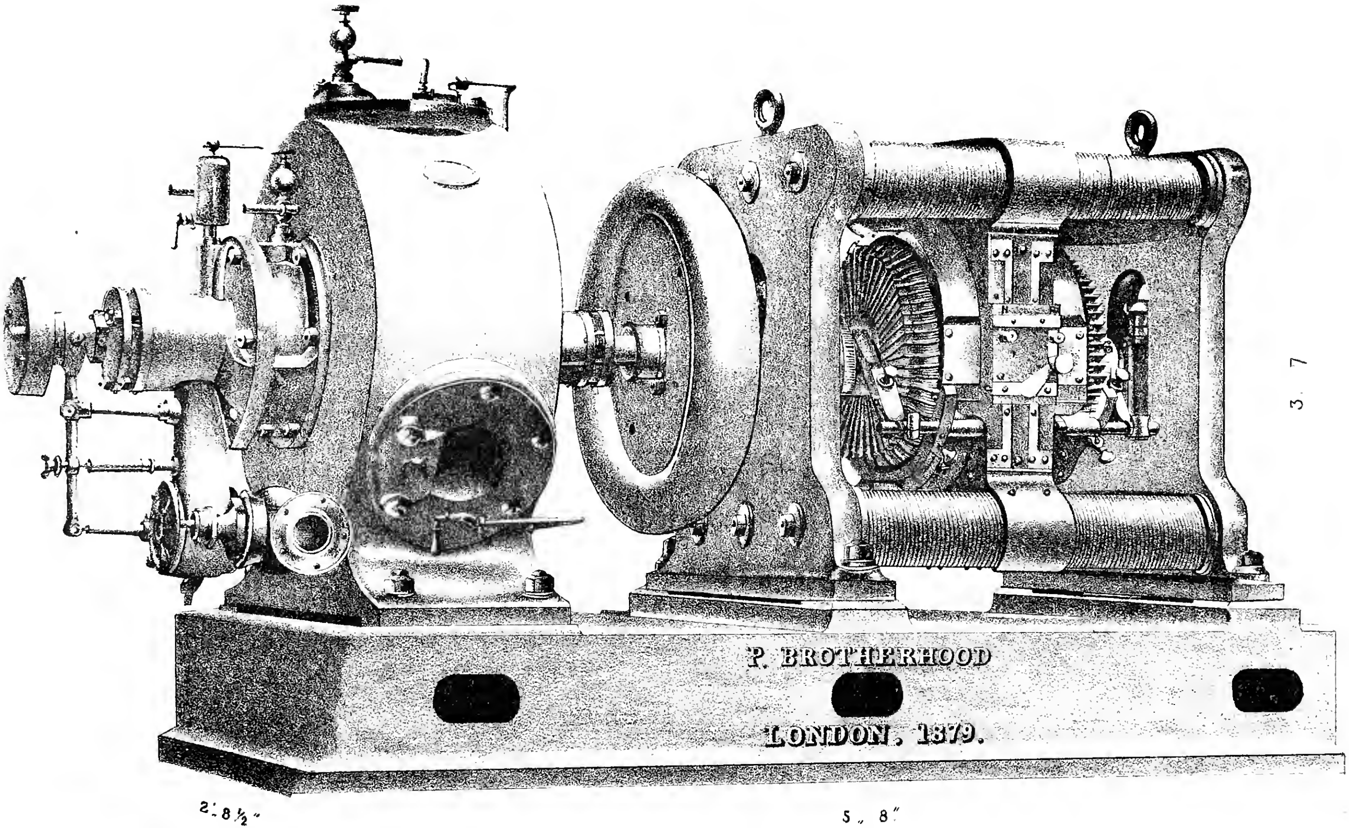
							E.M.F.								
															Gramme.
7.08	1350				1					17760	2312				M. Tresca with 2000-burner machine. Two armature coils in parallel arc. Gramme lamp. Gaudoin carbons 12mm. Admitted to have been made under more favorable conditions than would hold in practice.
2.81										2003	1033				M. Tresca with workshop type. Weight 400 lbs.
		43					40.		2.30	10500		4565			A Gramme—Ayrton & Perry—Sautter & Lemonnier lamp
		45.					42.		2.54	12200		4803			" "
15.1	500	93.78	0.326		1	0.045		11.15		27500	1821		85.11		D " Royal Engineers, Chatham
12.7	475	91.20	0.320	0.498	1	0.017		10.25	5.50	22500	1772	3057	81.82	43.8	" "
9.52	1200	81.22	0.21	0.627	1	0.860		7.61	5.54	10500	2048	3519	80.	58.2	C " Inclined carbons
9.55	875	68.81		.549	1	0.776		8.18	5.79	18300	1016	3161	85.65	60.6	2A " combined
5.30	420				1					4016	758				Old type—weight 2770 lbs. Tyndall
4.55	352	58.04	0.341			0.675	39.78	3.14					68.9		" " " " Prof. Farmer, Newport.
2.28	380	29.54	0.341			1.477	43.63	1.73					75.6		" " " " "
7.75	452	86.00				0.675		6.69					86.3		" " " " Trowbridge, Newport.
7.08	452	75.6						5.09					75.0		" " " " "
1.84	800	16.38	1.685	1.87	1	3.66	59.95	1.32	0.67	705	383	1052	71.5	36.6	" " 300 " Profs. Thomson & Houston, 1877.
															Brush.
15.48	770	10.04	10.55	4.33	16	83.51	839.02	11.285	9.575				72.9	61.9	C. F. Brush—No. 7 Machine
4.06	635	25.80	1.35	1.57	2	4.86		4.34	2.80	2213	892	1580	87.4	56.5	No. 3 machine wound for 3 lights } Torpedo Station, Newport. Each set the mean of from 7 to 9 observations.
4.87	615	24.31	1.35	1.50	2	4.74		3.75	2.38	2216	910	1862	77.0	48.9	
4.05	615	23.72	1.35	1.56	2	5.06		3.81	2.35	2186	883	1860	77.0	47.5	
5.52	650	23.25	1.35	1.48	2	4.91		3.55	2.15	2050	740	1015	64.3	39.	
3.20	1340	20.87	0.495	0.79	1	1.315	39.28	1.57	0.94	1230	377	783	48.1	28.2	No. 4—Profs. Thomson & Houston, 1877
		10.00					38.		0.51	1495		2927			Ayrton & Perry. Paris, 1881.
3.35					1					6650	1985				Prof. Morton, Dec. 12, 1879—Best observation. } Carbons out of line. Special machine for one light.
2.98					1					4290	1430				" " " " " Worst "
2.69					1					4800	1784				" " " 16, " Best " } Special machine. Carbons in line
2.90					1					4275	1474				" " " " " Worst "
															Siemens.
5.81	750	47.80	.69			1.64	76.32	4.83					84.2		As ordinary dynamo— } Dr. C. W. Siemens—"On the steadiness of the dynamo-electric current."
6.01	730	58.31	.69			1.40	70.48	6.21					90.		
3.08	504	39.03	.69			1.40	53.20	2.78					90.		
6.70	720	58.07	.69			1.40	79.16	6.16					91.		
2.86	612	30.72				1.25	48.22	2.56					89.5	62.03*	Dr. Siemens' Shunt dynamo. Armature res. .225—Field magnets 7.26
4.10	720	53.60				1.06	53.14	3.82					93.2	55.61†	" " " " " " .225 " " 4.28
2.42	600	31.30				1.87	54.65	2.29					94.5	81.40†	" " " " " " .166 " " 10.80
3.62	715	40.40				1.75	66.01	3.57					98.6	73.48*	" " " " " " .166 " " 7.26
4.11	702	40.40				1.55	58.47	3.16					78.8	52.62*	" " " " " " .166 " " 4.28
13.4	680	83.09			1	.948	79.55	8.06		10140	1420			66.87*	2 medium sized combined—Royal Eng., Chatham. Inclined carbons.
3.61	287	30.47	.48			.21		2.74						76.1*	Prof. Farmer, Newport—Shunt dynamo
4.48	314	40.65	.48			.21		3.024						67.5†	" " " " "
7.5	348		.38		1					5000 (300.)					" " " as ordinary dynamo
9.8	480				1					8032	911				Tyndall—large machine
3.3	850				1					4138	1254				" small "
6.6	850				1					8520	1291				" two small machines.
4.45					1					5568	1252				Prof. Morton—Medium size machine. Best result Nov. 14, 1879.
5.33					1					4389	824				" " " " " Worst " " "
4.45					1					4585	1030				" " " " " Maxim lamp. Best result Nov. 14, 1879.
5.33					1					5240	983				" " " " " " " Worst " " "
															Edison.
7.83		83.75		.76†		.773	64.74	7.27					92.7	88.8‡	Voltameter test. } J.W. Howell—B machine. Resistance of armatures and leaders .029. Magnet coils, 37.
7.86		88.97		.68†		.666	61.03	7.38					93.56	90.2‡	Calorimeter test.
6.90		88.14		.64†		.658	53.00	6.26					90.78	88.7‡	Electrical measurements.
															Weston.
6.596	690	18.45	2.11	8.30‖	7	11.49		5.243	3.786	1548	1642		79.5	57.4	Torpedo Station—Brush carbons $\frac{7}{16}$ in. } Each set the mean of from 5 to 10 observations.
6.8	700	18.61	2.13	8.20‖	7	11.88		5.372	3.89	1700	1750		79.0	57.2	" " "
9.59	920	18.41	2.15	13.51‖	8	16.80		7.033	6.138	1995	1600		79.0	64.0	" " "
9.56	920	17.73	2.13	14.53‖	9	17.88		7.54	6.138	1710	1610		78.9	64.2	" " "
9.48	930	17.65	2.13	14.67‖	10	18.10		7.557	6.124	1235	1300		79.7	64.6	" " "
10.33	935	19.30	2.15	13.76‖	8	16.99		8.507	6.900	2100	1626		82.9	66.8	Wallace " "
9.945	935	18.27	2.15	14.76‖	9	18.13		8.112	6.504	1796	1625		81.5	66.3	" " "
9.781	935	17.93	2.15	15.00‖	10	18.45		7.058	6.456	1217	1244		81.4	66.0	" " "
4.32					1					8406	1066				Prof. Morton—Nov. 21, 1879. Weston lamp. Best result.
4.583					1					5604	1230				" " " " " " Worst result.
4.552					1					6063	1332				" " " " " " Average "
4.28					1					8496	1084				" " " " Maxim " Best "
5.416					1					6018	1005				" " " " " " Worst "
4.683					1					7787	1663				" " " " " " Average "
5.11					1					12036	2350				Hand lamp. Best "
4.75					1					8142	1714				" " Worst "
4.77					1					8585	1800				" " Average "
5.06					1					7262	1436				Siemens lamp. " "
															Maxim.
5.31	805	37.78		1.27	1	2.52		4.82	2.43	7584	1428	3121	60.8	45.7	Torpedo Station—Mean of 8 observations.
4.64	865	20.80		1.44	1	2.64		3.14	1.71	6232	1343	3644	67.7	36.8	" " " " "
7.4					1					7524	1017				Prof. Morton—Low resistance machine. Average.
5.48					1					3997	729				" " Ordinary type. Average.
5.585					1					3930	704				" " " " Hand lamp. "
															Wallace-Farmer.
4.56	758	12.31					130.65	2.145					47.		Prof. Farmer, Newport.
4.116	765	12.96					126.54	2.197					53.		
4.26	747	12.53					124.65	2.086					49.		
2.94	844	10.42	4.46	1.98	1		81.59	1.14					38.7		Profs. Thomson & Houston—"Small Wallace."
3.89	1040	10.33	4.46	1.98	1		85.12	1.18		440	113		30.2		" " " "
	800				1					823					" " "Large Wallace."
5.3	770	13.00		2.5	1		131.			2439	460				Prof. Farmer—"Momentary maximum."
															Bürgin.
4.05§	1675	20.1			3					2720	1600**				M. Hagenbach.
3.75§	1675	18.2			4					1400	1120**				
5.52§	1675	21.5			3					4206	2310**				
4.14§	1675	16.0			4					2492	1840**				
3.67§	1550	15.0					186.	3.3					90.††		"Experiments at Chelmsford"—Engineering, Vol. XXXII, p. 205.
2.67§	1270	13.26					135.	2.4					90.††		
3.84§	1290 to 1340	20.21					138.	3.7					96.††		
				External Resistance										H.P. in external circ. / H.P. absorbed	**Crompton—Bürgin.**
7.10	1500	45.74	10.5	2.335		2.455	113.	6.90					97.2	65.0	Bobbin resistance .545—Field magnets 2 in series. } Measurements made at Crompton's works, Chelmsford
8.82	1520	52.90	10.5	1.822		2.005	110.	7.80						58.7	
8.20	1420	53.25	10.5	1.822		2.095	111.	7.92						64.6	
4.55	1420	30.20	42.0	3.32		3.605	111.	4.40						79.0	Bobbin .545—Field magnets in series. } Shunt dynamo.
6.44	1630	39.30	42.0	2.47		2.875	113.	5.92						71.3	
4.27	1650	23.24	42.0	5.89		5.705	132.	4.15						81.3	
5.44	1800	39.34	42.0	2.38		2.558	100.	5.39						82.7	Bobbin .298 " " " "
4.75	1820	29.10	42.0	3.36		3.418	99.	3.85						70.	
3.99	1800	21.95	42.0	4.46		4.338	95.	2.79						60.	
															Wilde.
5.16	508	61.76				.733							72.7		Prof. Trowbridge, Newport.
5.95	500	60.25				.907							74.1		
4.52	548	43.44				1.120							62.1		
7.28	520	44.94				1.453							56.		
8.46	528	32.86				2.305							39.4		
6.50	500									5700	900				Royal Engineers, Chatham.

* H. P. in external circuit / H. P. applied † External resistance. ‡ H. P. in external circuit / H. P. applied ‖ Resistance of arcs. § Horse power absorbed. ** Candles per horse power absorbed. †† H. P. of current / H. P. absorbed



I FRIEDENWALD LITH BALTO.

Motors.

As the E. M. F. depends on the velocity, a constant current requires a good motor. The prime requisite in a motor is regularity, and for this reason many common engines, among them the service donkey engine, are unsuitable. This regularity is more necessary for incandescent than for arc lighting, but no ordinary single cylinder engine can be thought to be a good motor for an electric light unless a large fly-wheel is used. In adopting a motor for shipboard, compactness becomes necessary, and all cumbersome machinery should be avoided. Belting would be inadmissible, and gearing should be avoided if possible, on account of the wear and noise attending the high velocities required. If extensive adoption is any test of efficiency the Brotherhood three-cylinder engine seems to be nearly all that could be desired, being almost universally applied in Europe to marine installations. It consists* of three cylinders symmetrically arranged around a crank pin, and in almost every position is worked by the same amount of power, a very delicate governor controlling the supply of steam, while regularity is still further attained by a small fly-wheel. It can be worked up to 2000 revolutions, and is durable and remarkably compact, the stroke of the piston seldom being over eight inches. It is not, however, economical, and the two considerations of compactness and economy are apt to conflict. In the recent Paris exhibition a great number of these machines were exhibited in connection with Gramme machines for various uses. For torpedo boats and steam launches the M Gramme was mounted on the same bedplate with the 2¼ inch Brotherhood engine, the whole installment occupying a space of 2′ 4″ in length, 1′ 2″ in width and 1′ 6″ in height, and weighing 310 pounds. The installation acknowledged in England and France as the best for a single search light is the D Gramme with 6″ Brotherhood engine. This occupies a length of 5′ 8″, a height of 3′ 7″ and width of 2′ 8½″, and weighs 4250 pounds. Working with 80 pounds steam, this engine has developed 13 H. P. at 500 revolutions. The plate shows the D Gramme with Brotherhood engine as fitted aboard the Inflexible, Sultan, Neptune, and the principal ships of the French navy.

At the recent exhibition at the Crystal Palace, Hodson's rotary engine was exhibited, connected directly to dynamo machines, and was said to give excellent results. In installations at shore stations

* See Engineering, Oct. 3, 1873.

gas engines could be used with economy, the Clerk gas engine, taking gas on every stroke, being probably the best, although the Otto is more widely known. Ashore, if steam were available, many engines could be used which would be inadmissible aboard ship, and there the most economical could be adopted, weight or space occupied being no disadvantage.

Arc Lighting.

Lamps—Many types of lamps have been introduced and work successfully in ordinary use which could not be adapted to use as a search light. Most lamps are regulated by the intervention of an electro magnet in the main circuit, by which one of the carbons is raised or lowered, work being thus done by the current outside the arc. These regulators sometimes have an appreciable resistance, and in that case energy would be lost which in a better arrangement might be utilized in the arc. Other types introduce clockwork gearing, so that the work of moving the carbons is not performed but only regulated by the current, an electro magnet moving an escapement device permitting the clockwork to move. In a search light a constant powerful light is needed, and this requires that the limits of the movements of the carbons should be small, that the arc may preserve a practically constant length and resistance. The movement must be such that the motion of the vessel would cause no irregularity of action, and arrangements should exist for accurate focusing.

The Chatham experiments decided in favor of the Serrin regulator if automatic regulation was thought necessary; but the best results were there given by the Sautter and Lemonnier inclined hand lamp. This lamp is the one figured in the Mangin projector, Fig. 2.

The hand lamp possesses many marked advantages over the automatic regulator, among which are the following:

1. Ease and rapidity of focusing.

2. Possibility of immediately regulating the arc, so as to obtain the maximum light, which is gained slowly in automatic regulators.

3. Possibility of keeping the carbons at such a distance as may be found best at the time.

4. Freedom from all irregularities of action caused by motion of the vessel or of the projector.

5. Simplicity and ease of action and freedom from derangement.

The disadvantage attending the use of hand lamps is the necessity of keeping a man at the projector to work it. If a screen could be

arranged to protect him from machine gun fire, he could work as long as the projector remained intact, and better results would unquestionably be given.

In order to utilize current energy in the arc it is necessary that there should be resistance, but other things equal, the light given out is greater with a less resistance, the light varying with the current. A practical minimum is imposed by the fact that if the carbons are very close together, although there may be an intense light in the arc, much is lost by reflection between the points.

The best results seem to have been given with an arc resistance of about half an ohm. As can be readily seen by projecting the carbon points on a screen, the greater part of the light comes from the points and not from the arc, and in order to obtain a powerful light, a large surface of the carbons should be heated to incandescence, requiring of course a powerful current. A strong current, moreover, decreases the resistance of the arc by raising its temperature, when it becomes a better conductor. Profs. Thomson and Houston, who were among the first exact experimenters on the electric light, summed up their observations as follows:*

1. In arcs of equal lengths, the resistances are inversely proportional to the currents.

2. The illuminating power of an arc is approximately proportional to the current.

3. In arcs of equal lengths the total energy given out varies as the current strength.

The exactness of these relations may be questioned, but they are approximately correct at least. They further pointed out that it is possible to have an increase of energy in the arc with an actual loss of illuminating power, the reason being that in a long arc, much of the energy is consumed in heating the vapor of the carbon, which in a short one could be utilized in raising more of the carbon to incandescence. The length of the arc does not, however, afford an accurate idea of its resistance. Dr. Paget Higgs † states that he has measured long arcs which gave more light and had smaller resistance than others of one-sixth their length. He attempts to prove that the light in an arc varies as the fourth power of the current. The Brush Electric Company of Cleveland state that in working the No. 7 Brush machine, adapted for one powerful light, the best results are produced

* Franklin Institute Journal, July, 1879.

† Candle Power of the Electric Light.

with an arc an inch or more long. As the light comes not from the arc but from the carbons, a *long* arc by exposing their surface freely would unquestionably be best, if the current is sufficiently powerful to make the resistance low.

Another peculiarity acting in opposition to the gain by a powerful current, is that a contrary E. M. F. is established in the arc, similar in effect to that due to polarization in the cell. Mr. Louis Schwendler gives the following figures illustrative of this:

Amperes.	Resistance of Arc.	— E. M. F.
16.27	1.83	1.86
23.87	1.60	1.91
28.81	.85	2.02

The measure of the efficiency of the lamp itself is the light given per H. P. of current in arc. This disregards all considerations of efficiency of machines, etc. The following is an abridgment of the tabulated results of Profs. Ayrton and Perry made at Paris last year.*

	E. M. F. Between Carbons.	Current	H. P. in Lamp	Candles.		Candles per H.P.		Mean Candles per H.P. in arc
				Red.	Green.	Red.	Green.	
Crompton	37.7	25.0	1.26	1849	2916	1467	2314	1890
Pilsen	36.8	10.33	.48	510	780	1066	1625	1345
Brush	38	10.00	.51	961	2025	1884	3970	2927†
Sautter Lemonnier, one lamp with A Gramme,	45	42.00	2.54	9025	15376	3553	6054	4803
Gravier	46.6	9.2	.58	349	1023	604	176-‡	1189
Serrin	31.1	35.8	1.49	938	2448	630	1616	1123
Carcel	51.8	16.7	1.16	1156	3445	997	2970	1983
Weston	33.7	21.7	.98	1024	2663	1045	2717	1881

The greatest difficulty has been experienced in making measurements of the electric light. The English standard, adopted also in the United States, is the standard spermaceti candle burning 120 grains per hour. The French is the "carcel," the lights given by a carcel colza oil lamp burning 42 grammes per hour. The latter may be taken as equal to 9.6 candles. The great difference of intensity between the electric light and either of these standards is an objection, but the chief difficulty arises from the marked difference of color, making exact comparison impossible. Still other difficulties arise from the great variations in the electric light from minute to minute, and

* Electrician, London, Dec. 3, 1881.

† Given in table as 1427. Evidently a mistake.

‡ " " " " 1173. " "

others in the variations of the light of the standard candle, which is far from possessing the invariability that should characterize a standard. For these reasons implicit reliance cannot be placed in even the most exact measurements, but such measurements are probably relatively correct within themselves. In the experiments of Profs. Ayrton and Perry a "dispersion photometer" was used, the intensity of the electric light being diminished in a known ratio by the interposition of a biconcave lens, and comparisons were made of the red and green rays in each light by the interposition of colored glasses. In this way the color difficulty was overcome, but the blue rays were not measured at all.

A most important point remains to be noticed. In an arc light worked by a continuous current, the end of the positive carbon becomes hollowed out, and it is found that the greater part of the light is radiated from this crater. Ordinarily the crater is turned down and the radiation is downwards, but by inclining the carbons, or placing them slightly out of line, the crater will be formed on one side of the point, and in that direction the light will be greatly increased. The following measurements are illustrative of this effect.

Authority.	Front.	Side.	Side.	Rear.	Mean.	In line.
Profs. Thomson and Houston . . .	2218	578	578	111	871	525
Douglass. Report to Trinity House .	287	116	116	38	134	...
Prof. Morton. Report to Lighthouse Board	7670	3115	4223	1682	4173	5105
" " " " .	6450	5000	3960	882	4073	4358
Torpedo Station, Newport	11000	...	...	...	6500	...

The increase of light in *one* direction is evident in each case, and this so exactly corresponds with the requirements of our case that it may be taken for granted that in any search light this advantage would be improved, either by placing the carbons out of line, by inclining the lamp, or by both means.

Mr. Crompton, in a lecture before the Royal United Service Institution, stated that from his observations, necessarily incomplete, he was led to think that the crater radiation possessed greater fog-penetrating power than any other, and as a method of detecting torpedo boats in foggy weather he recommends a light aloft, the crater radiation being thus thrown over a circle of which the ship is the centre. The inability of the electric light to penetrate fog is well-known, and it would seem as though this method would be of the greatest assis-

tance to the torpedo boats by producing a general brightening of the fog and indicating the position of the ship, while worthless as a means of detecting the boat itself.

Carbons.—A great difference exists in the luminous power of different carbons. The making of carbons has become a most important industry, and many devices have been tried with the idea of gaining advantages in the arc. Experiments have been made with salts of soda, potash and lime, but although certain advantages, as silent working or length of arc, may thus be gained, there is a loss of energy expended in volatilizing these substances, and a consequent loss of light. The vapor of these compounds, moreover, is better conducting than that of carbon and the resistance of the arc is thus diminished, and as carbon has proved to be the best material, so pure carbon gives better results than any modification. The following experimental results were recently presented to the French Academy of Sciences by M. Jacquelain: *

	Centim. consumed in 24 hours.	Carcels.
Graphite d'Alibert, not purified	90	55.14
Retort carbon, purified by potash	271	69.44
Retort carbon, not purified	300	71.9
Curmer carbons	390	82.6
Retort carbon, purified by HF	262	85.76
Hard lustreless carbons	115.3	100
Pure carbons, brilliant	288	100
Graphite d'Alibert, purified by HF	243	115.62

The French carbons seem to be regarded as the best, but as a rule waste faster and are much more expensive than ordinary carbons. Those made by the Brush Company are frequently spoken of as good working carbons, but with greater durability give less light. Tests at Newport gave Carré 3017 candles, Brush 1934, under nearly similar circumstances. At another time Carré $\frac{9}{16}$ in. gave 5500 candles with 34.9 amperes, Wallace $\frac{9}{16}$ in. 5263 with 34.36 amp. With $\frac{7}{16}$ in. the figures were 3100 and 3000 with the same current. The Carré carbons wasted much faster, and with pointed ends, giving no crater. The Wallace carbons cracked longitudinally, and had higher resistance. The following measurements on French carbons are taken from Fontaine's Electric Lighting:

* La Lumière électrique, April 29, 1882.

Retort carbon . . .	9^{mm} sq.	120 carcels.	Carbons were shaped very irregularly. Splinters numerous. Scintillation.
Archereau	10^{mm} diam.	173 "	Sparks. Disaggregation. Light very variable in intensity.
Carré	9^{mm} "	175 "	Small sparks. Arc running round. Very variable intensity. Good shaping.
Gaudoin, No. 1. .	11.2^{mm} "	203 "	Neither sparks nor splinters. Light a little red but quite constant.
Gaudoin (wood carbon),		240 "	Light very white. Less steady than Gaudoin No. 1. No sparks.

Another experiment gave the length of carbons consumed per hour as, Retort 63^{mm}, Archereau 85^{mm}, Carré 92^{mm}, and Gaudoin 73^{mm}.

Many carbons to-day are electroplated with a thin coat of metal, generally of copper. This coating prevents the loss of carbon by oxidation from the heat of the arc, and thus increases the time of burning, while not materially affecting the intensity of the light. The metallic coating decreases the resistance of the lamp outside of the arc, and admits of the use of longer carbons. Tests made in the works of Sautter et Lemonnier are as follows: *

	Diam.	Length consumed per hour in mm.			Light in carcels.	
		+	—	Total		
Naked	7^{mm}	166	68	234	947	A G Gramme, 950 revolutions.
Copper-plated	"	146	40	186	947	
Nickel-plated	"	106	38	144	947	
Naked	9^{mm}	104	50	154	528	
Copper-plated	"	98	34	132	553	
Nickel-plated	"	68	36	104	516	

The lessened consumption per hour is very noticeable.

Projectors.—A search light not only requires a high luminous power, but also that it should be capable of accurate concentration on any point. For the detection of torpedo boats, an apparatus giving moderate horizontal divergence would be best, as it would illumine an arc of the horizon at once; but when the position of an enemy was

* La Lumière électrique, January 29, 1881.

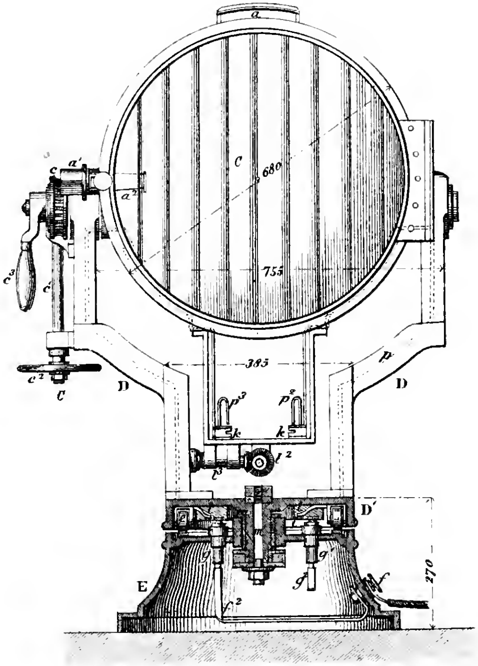
once discovered, this divergence might be practically a waste, as concentration would then be desired on one object only. It would, moreever, be desirable that there should be as little light lost as possible which might reveal the exact position of the vessel to the enemy. For war use, therefore, a projector should be capable of utilizing nearly all the light of the arc, and of projecting it in a parallel beam to a great distance.

The most common form is that of a parabolic reflector. This is theoretically correct, but has serious disadvantages. That parallelism may be secured to the reflected rays it is necessary that the luminous body should be a mere point in the focus, and the small electric arc is still sufficiently large to cause dispersion into a cone of light. The larger the mirror the less this divergence would be with an arc of a given size, but large mirrors are cumbersome, and apt to lose their exact shape by their own weight. A true parabolic mirror is, moreover, very difficult of construction, and all mirrors possess the disadvantage of requiring frequent cleaning, by which the reflecting character of the surface finally becomes impaired. For these reasons parabolic mirrors have been abandoned for lighthouse use, and experiments with lenticular apparatus have given a great increase of concentration.

In the use of lenses there are several sources of loss, the principal being spherical aberration, chromatic dispersion, absorption and reflection at surfaces. In a projecting apparatus a short focal length is a necessity, and this would greatly increase the loss by aberration, dispersion and reflection if a common lens were used. The cost is also a most important consideration, and for these reasons the Fresnel lens has come into extensive use in lighthouse illumination. As a projector, however, it possesses disadvantages. If the aperture of the lens is too large there is an excessive loss by aberration and reflection near the edges, and yet on account of the necessity of a short focal length the aperture must be considerable. The compensation is inexact, the lens being made of only a small number of rings, and there is a considerable amount of chromatic dispersion. Only a portion of the light from the lamps falls upon the lens, and in order to utilize the remainder Siemens has placed a spherical reflector behind the lamp. In projectors made by him and by Sautter et Lemonnier, the lens is surrounded by a series of catadioptric rings, the whole apparatus occupying a hemisphere. By placing the carbons out of line, ninety per cent. of the light may be made to fall on this hemi-

MANGIN'S PROJECTOR.

Fig.1.



From Giornale di Artiglieria e Genio.

Fig.3.

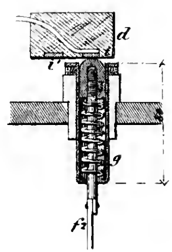
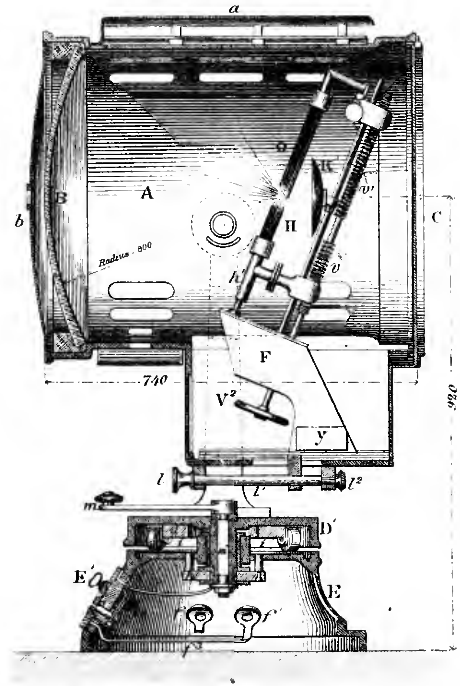


Fig.2.



I. FRIEDENWALD LITH. BALTO

sphere, and the spherical mirror behind the lamp is therefore frequently omitted. This kind of projector is theoretically exact, but is open to the same objection as the parabolic mirror; it requires a point as a focus. The focal distance is so short, moreover, 15 cm., that the glass is liable to be cracked by the heat, and a slight displacement or lengthening of the arc produces a great divergence of the beam of light. It gives a much greater luminous power than the reflector, but is open to the same general objection of want of parallelism in the emergent rays.

The projector in use in European navies is that invented by Col. Mangin, and overcomes these difficulties. It consists of a concavo-convex lens, the convex surface having the greater radius. The concave side is turned to the light, and the convex surface is silvered. It is therefore a reflector, but the radii of curvature of the faces are so calculated that the two refractions at the concave surface almost completely destroy all aberration, and this gain more than counterbalances the loss by reflection. The beam has a divergence of only 2°, being only 15m. in diameter at a distance of 1000 metres. By moving the lamp slightly away from the mirror the divergence can be increased. This projector was recommended as the result of the Chatham experiments. That of 90 cm. diameter was stated to give twice the light of that of 60 cm. It is made by Sautter et Lemonnier of the following sizes, and is furnished with lamp and connections complete:

30 cm. diam., focal dist. 16 cm.	60 cm. diam., focal dist. 33.2 cm.
40 " " " " 24 "	90 " " " " 76 "

In the accompanying figure the projector B is placed at one end of a cylinder A, in which openings covered with concentric plates are arranged for the escape of hot air. The cylinder is supported on trunnions, one of which carries a screw thread c (Fig. 1), connected with the endless screw on the axis c^1. By turning the wheel c^2, any desired elevation or depression can be given, and the cylinder held firmly in place by the clamp c^3. The tube a^2 carries at one end a small lens and at the other a total reflecting prism, and is directed towards the focus of the mirror. By this the person in attendance can examine and focus the carbons. The trunnions of the cylinder are supported by two iron arms, D, in each of which an insulated copper wire is placed, as shown by the dotted lines. The arms rest on a disc D^1, which turns by means of bronze rollers e on the bedplate E, motion being given by the handle m (Fig. 2). Attached underneath the disc D^1 is a piece of wood bearing on its under surface two concentric bronze rings, connected with the copper wires p. Against each of these rings presses a metal cap j (Fig. 3), kept in contact with it by

the spring g. The current then entering at f (Fig. 1), passes through f to g, thence to one of the bronze rings, and by the wire in the branch D to the plate p^3. The return is the same, but a switch is introduced at E^1. The figure shows the inclined hand lamp of Sautter et Lemonnier in position, but admitting of slight displacement by the screws l and l_3. On the sides of the base of the lamp are plates y (Fig. 2), which are in contact with the wires p_2 and p_3 (Fig. 1). The current ascends through the metal of the regulator and the screws v and v^1 to the upper carbon, and from the lower carbon through an insulated wire inside the tube h^1 to the other terminal y. A small mirror K^1 is placed behind the arc, and in the large projectors a converging lens is sometimes placed between the arc and the mirror to intercept rays that otherwise would not have struck the mirror. The door C (Fig. 1) causes the rays to diverge in a horizontal plane. A general divergence of the beam can be given by moving the lamp by the screw l. The figures and accompanying explanation are taken from the *Giornale di Artiglieria é Genio*, April, 1882.

Incandescent Lighting.

The question of arc search lights has been examined as one of necessity, but incandescent lighting cannot be treated in the same way. The lighting of our ships by electricity would unquestionably be a source of great convenience and comfort to the officers and crew, and would conduce greatly to health, avoiding the hot, poisonous gases given off by candles and lamps in the confined and crowded berth-decks or steerages, and as more attention is now being paid to questions of ventilation and of hygiene in general, incandescent lighting merits attention. Its chief recommendation is freedom from heat and bad gases, the only objection its cost; but with dynamo machines aboard, the latter would be narrowed to the cost of coal consumed. There can be but little doubt that incandescent lighting would be more expensive than oil, but it would be vastly more effective, and if expense is subordinate to health and comfort there remains no reason why it should not be introduced. The Inflexible is lit by Swan's lamps, and numbers of merchant steamers use the electric lamp entirely, so that there can be no question of the practicability of the plan, and with the introduction of other modern improvements into our navy the incandescent lamp would naturally take its place on shipboard. One of the most serious difficulties would arise from the breakage of lamps, necessitating renewal, and a ship going on a long commission would therefore require a large number of spare lamps, which would be exposed to breakage long before they could be used; but with the extensive adoption of the electric lamp, which is probable in a few years, they could be pur-

chased in almost any port in the world. It is possible that some of the semi-incandescent lamps might be of use, as they require only renewal of carbons.

The approved types of incandescent lamps to-day all use a small fibre of carbon which is heated white hot by the passage of a current through it. This fibre is obtained by heating some vegetable substance containing it, out of contact of air, and driving off all volatile matter. Edison uses bamboo fibre, Swan cotton thread, Lane-Fox a grass fibre, and Maxim paper. This fibre is mounted in a vacuum, on the perfection of which depends greatly the lifetime of the lamp, the presence of a small amount of oxygen insuring the rapid destruction of the fibre by chemical action. Even in a perfect vacuum the fibre would eventually give way, on account of what is called the "Crooke's effect," a molecular transfer from one heel of the carbon across to the other. Alternate current machines prevent this action to a great extent, and lamps for continuous currents have been made with one end of the carbon filament thicker than the other. In spite ... there is a lifetime for every lamp. The

ERRATUM.—On page 372, line 3, should read:—to the plate p^2. The return is by plate p^3, but a switch is introduced at E^1.

Thus at the ...
was established on August 11, 1881. Up to December 9, 41 lamps had been put in place, 24 having failed. Of the 17 remaining in good condition at the latter date, four had been used 1040 hours, three 800, and one each for 750, 680, 640, 600, 560, 510, 500, 430, 400 and 110 hours. The average life was 220 and the shortest 10. The Edison Company guarantee an average life of 600 hours, and state that double this is often obtained.

The conditions of incandescent lighting are widely different from those already considered. In this case the light is given from a portion of the circuit which is heated white hot by the passage of the current, and this requires that that portion should be of high resistance, and practically infusible. After long experimenting, carbon has been fixed upon as the best material, and it is now used in all types of incandescent lamps. It will be readily

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The lifetime of a lamp is important, but is not fixed. Although the greatest advances have recently been made in the manufacture of carbons, perfect homogeneity seems impossible, and even uniform durability cannot be secured. But few data as to the lifetime of lamps are accessible, and those that are show wide discrepancies. Thus at the Earnock Colliery an installation of 17 Swan's lamps was established on August 11, 1881. Up to December 9, 41 lamps had been put in place, 24 having failed. Of the 17 remaining in good condition at the latter date, four had been used 1040 hours, three 800, and one each for 750, 680, 640, 600, 560, 510, 500, 430, 400 and 110 hours. The average life was 220 and the shortest 10. The Edison Company guarantee an average life of 600 hours, and state that double this is often obtained.

The conditions of incandescent lighting are widely different from those already considered. In this case the light is given from a portion of the circuit which is heated white hot by the passage of the current, and this requires that that portion should be of high resistance, and practically infusible. After long experimenting, carbon has been fixed upon as the best material, and it is now used in all types of incandescent lamps. It will be readily

seen that the interposition of one high resistance lamp in the circuit of a small dynamo machine would reduce the current to small dimensions, and that two placed in series might reduce the current so low that they would give but little light. By arrangement, however, in parallel arc the external resistance may be reduced to any required extent, and several lamps might be utilized. Thus, take the case of a battery or machine having an E. M. F. of 200 volts, with an internal resistance of 5 ohms, sending a current through a lamp whose resistance is supposed to be constant at 100 ohms, and requiring a current of one ampere to give its normal light. Placing two lamps in series, the current would be $\frac{200}{200+5} = .975$ amperes, or not sufficient for the lamp at its normal standard. In parallel arc the same machine would light 20 lamps, thus $\frac{200}{\frac{100}{20}+5} = 20$ or 1 ampere in each lamp.

It is at once apparent that to secure a uniform distribution of light by this arrangement the lamps must be of equal resistance, otherwise some would have stronger currents passing than others. As will be shown from the tables hereafter, lamps of high resistance are the most efficient, and these two requirements must be met in any system to secure good and economical working. The subdivision in parallel arc cannot be carried on indefinitely, as the good working of the machine limits the minimum external resistance. With the increase of the number of parallel arcs comes also the increase of the parts into which the current is divided, and a limit would be reached when a sufficiently strong current did not flow through each lamp. Thus the machine above would not work 21 lamps at their normal power:

$\frac{200}{\frac{100}{21}+5} = 20.47$ amperes, or .975 per lamp.

The following measurements made at the Torpedo Station at Newport are exceedingly well adapted to show the relations existing in incandescent lighting, and are valuable, moreover, as showing the efficiency of Edison's new lamps. A lot of 24 lamps were arranged in parallel arc, and were worked by a Maxim No. 8 machine. The resistance of the lamps varied between 122.5 and 134 ohms, and photometric measurements were made on the lamps of the least and of the highest resistance.

Edison's Lamp of Lowest Resistance.		
Current.	Res. of Lamp.	Candles.
.000	122.5	Lamp cold.
.007	122.0	
.014	121.2	
.021	118.7	
.038	113.9	
.073	106.6	
.115	101.2	Loop turning grey.
.139	98.0	Part of loop dark red.
.169	94.9	Greater part of loop red.
.189	93.2	All red. Part light red.
.251	89.6	Orange.
.290	85.3	Bright orange.
.373	79.3	Candles, .8
.599	72.5	" 1.9
.700	64.3	" 4.6
.792	62.5	" 9.6
.878	60.7	" 13.3
.930	60.4	" 20.3

Edison's Lamp of Highest Resistance		
Current.	Res. of Lamp.	Candles.
.000	134.	Lamp cold.
.114	110.5	Cherry red.
.203	94.7	Bright red.
.309	86.7	Orange.
.440	81.8	Candles, 1.8
.680	73.5	" 7.2
.750	72.8	" 11.4
.810	70.6	" 16.4
.890	69.9	" 21.0
.900	69.5	" 22.0

The prominent feature in these measurements is the rapid decrease of the resistance of the lamp with the increase of the current. The photometric measurements were taken on the side of the loop, and are the maximum light given by the lamp. From these measurements the following efficiencies are computed:

Edison Lamps.	Current in one lamp.	H. P. consumed.	H. P. in circuit.	H. P. in lamps.	Total candles.	Candles per H. P. consumed.	Candles per H. P. in lamp.
Lamp of lowest resist. 122.5	.878	2.89	2.17	1.40	319.2	110	228
" " " " "	.930	3.24	2.63	1.65	487.2	150.4	295.3
" " highest " 134	.810	3.31	2.59	1.68	393.6	119.	234.
" " " " "	.900	3.34	2.83	2.04	528.0	158.	259.

The last two columns indicate the higher efficiency of the lamp of high resistance with the same current, and show with both lamps that greater economy is found with the strongest current. But the life-time of the lamp is shortened by using a powerful current, and the fibre may give way even when new if the current becomes too strong. In these experiments one carbon broke with a current of a little less than an ampere.

The Maxim is another lamp of American manufacture, and the following measurements were made at the Torpedo Station. One lot of twelve lamps varied in resistance from 24 to 90 ohms.

MAXIM LAMPS WITH MAXIM MACHINE.

Current.	Res.	Candles.	Current.	Res.	Candles.
.000	44.4		.000	30.2	
.324	17.9		.79	17.9	Dark.
.449	15.92	Dark red.	1.63	15.8	.1 candles.
2.22	14.91	.9 candles.	1.76	15.8	.18 "
3.29	12.32	19.3 "	1.97	15.6	.77 "
4.78	11.22	124. "	2.45	14.9	4.70 "
			2.65	15.1	7.70 "
			3.22	14.6	23.97 "
			3.34	14.3	41.5 "
			4.04	14.3	56.5 "
					Stopped and allowed lamp to cool.
				28.8	Cold.
			5.3	13.2	298
			5.7	14.0	880
			5.9	14.0 (?)	920
			6.0	Carb. broke.	1200 estimated.
			Before the carbon burned, the wooden lamp-stand took fire at the junction with the platinum.		

The resistance of this lot of lamps varied too much. Another lot of twelve varied in resistance (cold) from 69.08 to 77.67 ohms, a marked improvement.

From the above the following efficiencies can be computed:

	Current.	H. P. in lamp.	Candles.	Candles per H. P. in lamp.
Res. of lamp, cold, 44.4	3.29	.2799	19.3	68.9
" " " " 44.4	4.78	.3435	124	364.7
" " " " 30.2	3.22	.2029	23.97	118.1
" " " " 30.2	4.04	.2333	56.5	242.5

The same relations are indicated as before, and the lamps at about 20 candles are much less efficient than those of Edison.

Prof. Morton experimented with Maxim lamps for the Lighthouse Board, and his results are given as follows in Report for 1880. The same report contains experiments made on Edison's old lamp, the carbon being made from charred paper.

MAXIM LAMP.

Designation of lamp.	Current by Volta-meter.	Current by Galv.	Resist. of lamp. Cold.	Resist. of lamp. In exper.	Foot lbs. in lamp.	Lamps per H.P. of current.	Candles.	Candles per H. P. in lamp
C . . .	4.07	...	20.4	8.3	5843	5.6	50	280
A . . .	2.95	2.85	31.8	14.5	5500	6.	40	240
B . . .	1.35	1.38	115.	64.	5100	6.47	52	336
	1.35	1.23	115.	65.	3372	8.52	23	195
E . . .	2.67	2.23	36.	21.1	4767	6.92	53	366
Large . .	4.405	...	14.35	7.3	6232	5.29	38	201
" . .	5.23	5.35	14.35	6.8	8184	4.	90	362
" . .	6.336	..	14.35	6.6	11656	2.83	200	566

Prof. Morton calls attention to the fact that the same efficiency can be secured from lamps of low or of high resistance if the current is properly proportioned. Thus, the B lamp with 1.35 amperes has nearly the same efficiency as the large lamp with 5.23 amp.

The lamps of Swan and Lane-Fox are in extensive use in England, and the former have been introduced aboard many transatlantic steamers and a few vessels of the Royal Navy. They are generally worked by Siemens' alternate current machine, and the Lane-Fox lamps by the Brush.

The late Paris exhibition afforded a good opportunity to test the different incandescent lamps, and a careful series of measurements was made by a committee, among the members of which were Prof. Barker, Mr. William Crookes, Major Armstrong, and other well-known experts. The report of this committee is published in full in the *Electrician*, June 17, 1882, but it is not necessary to give more than the finding. Each lamp was tested at or near sixteen candles, and again at thirty-two, and as these powers are such as would be naturally used in a system of incandescent lighting, the results are almost decisive in the present stage of the question.

At or near sixteen candles:

	Resistance cold.	Resistance at time of measurement.	Volts.	Amperes.	Volts-Amperes.	H. P. of current in one lamp.	Candles.	Lamps of sixteen candles per H. P.	Candles per H. P. of current.
Edison....	241	137.4	89.11	0.651	57.98	.0778	15.38	12.28	196.4
Swan......	59	32.78	47.30	1.471	69.24	.0928	16.61	11.12	177.92
Lane-Fox	55	27.40	43.63	1.593	69.53	.0925	16.36	10.85	173.58
Maxim....	72	41.11	56.49	1.38	78.05	.0144	15.96	9.45	151.27

At or near thirty-two candles:

	Resistance cold.	Resistance at time of measurement.	Volts.	Amperes.	Volts-Amperes.	H. P. of current in one lamp.	Candles.	Lamps of thirty-two candles per H. P.	Candles per H. P. of current.
Edison....	241	130.03	98.39	0.758	74.62	0.100	31.11	9.60	307.25
Swan......	59	31.75	54.21	1.758	94.88	0.1272	33.21	8.20	262.49
Lane-Fox	55	26.59	48.22	1.815	87.65	0.1175	32.71	8.65	276.89
Maxim....	72	39.60	62.27	1.578	98.41	0.1319	31.93	7.48	239.41

In copying the table, kilogrammetres have, for convenience, been changed to H. P.

The committee present the following general conclusions:

1. "The maximum efficiency of incandescent lamps in the present stage of the subject and within the experimental limits of this investigation, cannot be assumed to exceed 300 candle lights per H. P. of current.

2. "The economy of all lamps of this kind is greater at high than at low incandescence.

3. "The economy of light production is greater in high resistance lamps than in those of low resistance, thus agreeing with the economy of distribution."

The committee also reported on the efficiency of each lamp as given in the tables.

Other experiments less comprehensive than those given could be quoted as giving the same relative efficiencies, and in summing up the present state of incandescent lighting, only one conclusion seems possible, that being that the Edison lamps are more efficient than any other. Edison, moreover, presents his lamps, not as an independent invention, but as a part of a thoroughly organized system, every part of which is adapted to the requirements imposed upon it, and it is to his system that we must look for the solution of the question of the economy of general lighting by electricity.

Secondary Batteries.

The secondary battery, although indirectly connected with our subject, is of the greatest importance, and contains in itself so many possible applications as to require notice. The secondary cells in use to-day are all based on the same principle. By means of the electrolytic action of a current passed between two lead plates,

generally coated with red lead and immersed in dilute sulphuric acid, oxygen is deposited on the anode, while the kathode is deoxydized. If this action could be carried on perfectly, there would finally result one plate of pure lead and the other of lead peroxide, the latter being highly electro-negative to the former. The process is simply one of polarization, which is so detrimental in the ordinary voltaic cell, but is utilized in the secondary. Once charged, the cells remain almost unchanged until the external circuit is closed, when a current flows in the opposite direction to that used in charging. The chemical action actually taking place is probably by no means as simple as this, and to the presence of sulphate of lead and unreduced oxides on the kathode may be due the fact that Faure's cells seldom give the theoretical E. M. F. due to lead and lead peroxide.*

Secondary batteries are in use to a certain extent in many systems of electric lighting, being placed either in the main or a shunt circuit, so that in case of a failure of the dynamo machine the cells could supply a current which would still keep the lamps lighted. This is a most important advantage and one that will greatly increase the probability of incandescent lighting becoming an established fact in cities; but the cells admit of another use which more particularly fits them for use on shipboard, that of storing electrical energy. The Atlantic steamship Labrador was lighted during an entire passage by secondary batteries charged *before starting*. It would undoubtedly have been more economical to have charged the cells by a dynamo aboard ship, and shortened their period of inactivity, but this experiment is important as showing the practicability of the plan. Except in the largest class of men-of-war, it is doubtful if steam would be kept up continually in times of peace, and a dynamo machine could not therefore be used alone for incandescent lighting; but if steam were gotten up once a week, the secondary batteries could be charged and used as needed in the interval. In spite of the loss by the deterioration of the cells when idle, this would probably be much more economical of coal than it would be to run the dynamo every night, banking fires during the day.

Probably the most valuable test yet made of secondary batteries for incandescent lighting is that conducted by a committee at the Paris Exhibition, the report having been presented by the Chairman, M. Tresca, to l'Academie des Sciences.

* For the chemical processes in charging see Electrician, Mar. 25, 1882.

The following is a summary of the results obtained.* Thirty-five cells, each weighing complete 43.7 kilos, were charged by a Siemens shunt dynamo. In discharging the current was passed through eleven Maxim lamps, one of which was placed in a photometer:

CHARGE.

Date and duration of charging.	H.	M.	Work by dynamometer. Kilogrammetres.	Mean E. M. F. Volts.	Mean Current. Amp.	Quantity electricity supplied. Coulombs.	Work of charge. Kilogrammetres.	Work Unavailable. Kilogrammetres.	
Jan. 4,	5	30	2,414,907	82.21	10.93	216,400	1,814,600	In Armature,	269,800
5,	7		2,772,292	91.08	7.97	200,800	1,947,100	In Magnet Coils,	1,883,600
6,	7	30	3,246,871	92.91	7.94	214,300	2,028,800	Lost in Transmis-	
7,	2	45	1,135,728	92.06	6.36	63,000	591,600	sion,	808,750
	22	45	9,569,798			694,500	6,382,100		
			808,750						
Work absorbed			8,761,048						

DISCHARGE.

Date and duration.	H.	M.	Mean E. M. F. of Battery.	Mean Resistance. Ohms.	Quantity of electricity discharged. Coulombs.	External electrical work. Kilogrammetres.
Jan. 7,	7	19	61.39	16.128	424,800	2,608,000
9,	3	20	61.68	16.235	194,800	1,204,000
					619,600	3,809,000

The mean light of the lamp observed was 1.4 carcels for 10 hours and 39 min., or 149.1 carcels for one hour for eleven lamps, an average of a little over nine carcels per H. P. of current. The experiment ended when the light became too much diminished for practical use, although the cells were not fully discharged.

In calculating the efficiency, the efficiency of the whole system equals

$$\frac{\text{Electrical work returned}}{\text{Work expended}} \text{ or } \frac{3,809,000}{9,569,798} = 39.7 \text{ per cent.}$$

The efficiency of the dynamo and cells is

$$\frac{\text{Work returned}}{\text{Work absorbed}} \text{ or } \frac{3,809,000}{8,761,048} = 43.5 \text{ per cent.}$$

The efficiency of the battery alone is

$$\frac{\text{Work returned in current}}{\text{Electrical work of charge}} \text{ or } \frac{3,809,000}{6,382,000} = 60 \text{ per cent.}$$

* Electrician, Jan. 21, 1882, and Apr. 22, 1882.

It is noticeable that nearly all the electricity of the charge is returned, the ratio being $\frac{619,600}{694,500}$ or 89.8 per cent., but at the mean potential of 61.5 volts instead of 91 as in the charge.

In charging secondary batteries a certain E. M. F., probably about 2.5 or 2.6, is necessary to cause the electrolysis, the E. M. F. of polarization having to be overcome. A less E. M. F. than this will not allow of the deposit of the lead peroxide on the anode, but as the electrolysis is done by the current, a powerful current is needed with this low E. M. F., necessitating, of course, a small resistance. So far as the secondary cell is concerned the best charge would be given by a voltaic battery arranged in multiple series to meet the above requirements, but as voltaic electricity is too expensive, the most economical method of charging is by a dynamo machine, the cells being arranged in series, and the E. M. F. of the machine such as to give about the proper difference of potential between the terminals of each cell. Charging with too high an E. M. F. would cause heating of the cell, and this is not only a waste of energy, but a direct loss, as the E. M. F. of polarization, or the potential at which electrolysis can commence, is lowered by an increase of temperature. Electrical energy being represented by C E, and the current remaining practically constant, the lowering of the electromotive force of polarization would cause less energy to be stored in the cell, and of course less could be taken from it.

Faure's cells were thought on their first introduction to be a great advance on the earlier invention of Planté. They are more easily charged, but many experts prefer the action of the Planté, thinking it more reliable and durable. The chief deterioration of the cell comes from the formation of lead sulphate on the peroxide plate. In a paper read before the American Association, in August, Prof. G. F. Barker stated that he found this action to be greatly lessened when the lead peroxide was in a crystalline condition, and that this condition was more readily secured in the Planté cell than in the Faure, enabling the former to preserve a higher E. M. F.

Many of the defects of the present secondary batteries may yet be remedied and their efficiency increased. Their weight is a serious objection in shore use, but would admit of their being used as ballast on shipboard, and utilizing space that has heretofore been wasted. Electricity already has many uses in warfare, and will undoubtedly become still more important, and the advisability of having a reservoir

of electric energy always available will then be indisputable. Sir William Thomson states that "a Faure accumulator, weighing three quarters of a ton, will continue to work six hours from one charge, at the uniform rate of one horse-power per hour." If the dynamo machine is adopted generally in men-of-war, the secondary battery would be its natural adjunct.

Transmission of Energy.

The most important property of the dynamo machine is that it affords a vehicle for the transmission of energy to a distance. A dynamo which when worked will generate a current, will conversely work when a current is sent through it, but this property, so important in engineering operations ashore, would seem to have fewer uses on shipboard. When one dynamo machine works another, the latter gives off the most work when its speed is half that of the generator, and then gives one-half the energy of the first, the other half being wasted as heat in the resistances. A much larger *proportion* can be utilized by making the velocity of the second machine almost equal to that of the first, but in this case less energy is transmitted. For such short distances as we have on shipboard, vastly better efficiency would be gained by the use of steam engines placed where needed, fed through steam pipes from the boilers, but the reversibility of the dynamo machine might be of great service in the propulsion of torpedo boats or movable torpedoes, each fitted with a small electro-motor. If secondary batteries were in use, a torpedo boat could be started on its course and controlled in its movements the moment it touched the water, whether steam were up or not.

Details.

It now remains only to consider some of the details of the arrangement aboard ship. To save space and avoid gearing or belting, the engine and dynamo should be on the same bedplate. The boiler might be near, but in all probability one of the ship's boilers would be used. The machine might be in the engine room, but much better by itself on either the gun or berth deck. It should not be near the compasses* or navigator's store-room, and should in any case be

* Comd'r Bartlett states that a No. 4 Brush machine used aboard the Coast Survey steamer Blake caused, when in motion, a deviation on some courses of one and a half points, the standard compass being about fifteen feet from the dynamo.

screened by a bulkhead or high railing, to prevent danger from the carelessness or ignorance of the crew. The presence of a powerful dynamo in a crowded ship involves danger, but with proper precautions this would not be great. This danger is of two kinds, personal and that of fire. The former would arise from the number and the ignorance of the crew, and could be avoided by careful insulation. Serious accidents could arise only from both conductors being touched at once, and this could be effectually avoided by having the two branches of the circuit on opposite sides of the ship. The conductors should be of large cross-section, covered with insulating material, parcelled with tarred canvas or other suitable material to protect the insulating layers from chafe, and then boxed in some light covering so as to be easily accessible. Danger would then exist only at the terminals at the machine and the lamp, and the men on duty at these points would have sufficient understanding of the danger to avoid it. It would be well, however, even here and also in the lamp itself to have the circuit so protected that two parts at widely different potentials could not be touched at once. The physical danger depends on the E. M. F., and as a high potential also increases the leakage in the conductors, a moderate E. M. F. only should be employed, and a powerful current obtained, as already stated, by diminishing the resistance. It is on this account that alternate currents are so much more dangerous than continuous, the induced E. M. F. of the extra current being much higher than that of the primary.

Danger of fire would be extremely remote, and is referred to only because it is frequently advanced as an objection to electric lighting. In the circuit it could arise only from some portion of the conductor being so reduced in section as to have a high resistance, and consequently becoming so highly heated as to set fire to the insulating material. By making the conductors of copper and of large size this risk would be practically nothing. A sudden break in the circuit would induce an extra current of high E. M. F., and this would form a large spark between the two broken ends which might cause fire. Copper, however, is not apt to break, and a cable conductor might be more durable, as yielding more easily to the working of the ship.

At the lamps care should be taken that particles of incandescent carbon could not fall on combustible material.

The search lights would probably be placed at the ends of the bridge, or in ironclads on top of the turrets. The whole circuit might be double for convenience in case of injury, but the conductors should

not pass near enough to any of the compasses to affect them. Whatever projector is adopted should have an automatic motion of 180° sweeping the horizon from dead ahead to directly aft, and it should also be fitted to move by hand to keep the light directed on any desired object. At Newport an electro-motor placed in a shunt of the main circuit has been tested, giving a semi-revolution of the projector in from 50 to 75 seconds. It may be accepted as a fact that the light will become an object for small arm or machine gun fire, and as it might be necessary to keep a man near it, protection should be furnished him. Experiments were recently made aboard the Sultan of placing the lamp on the gun-deck, and projecting the light up through a vertical tube surmounted by a rotating iron hood containing a mirror, by which the beam of light could be given any desired elevation or direction.

Masthead and side-lights could be easily fitted, care being taken to avoid risk of injury to the crew. The former would require a base plate sufficiently large to cut off light that would dazzle the lookout men on the forecastle. If they were in darkness, and a powerful masthead light were fitted with a plane reflector behind it, they might be able to detect dangers ahead, such as vessels without lights, or ice, and avoid collision.

In time of war picket launches should be fitted with a small light apparatus. These are made of remarkably small weight and bulk, and would be invaluable in patrolling a channel on blockade, in detecting the approach of enemy's boats before they could be seen from the ship, and in signalling. Tests have shown that one of the easiest ways of signalling is by throwing the light beam on the sky and moving it from side to side as in the army code.

With the development of electrical apparatus will arise the necessity of having petty officers and men skilled in its use. A man may be an excellent mechanic but no electrician, as something more than mere mechanical skill is necessary; and with the introduction of the dynamo machine, search lights, incandescent lamps and secondary batteries into our men-of-war, we must provide men understanding their uses and capable of controlling or repairing them. Could not such naval apprentices, or seamen-gunners, as show any capacity for the work, be trained to it in the gunnery ship at Newport, and sufficient pay be assigned them to make the duty a desirable one, thus insuring the possession of capable men? If our coming navy is to be as efficient as the country wishes it to be, electricity will play an

important part in it, and the presence of men skilled in the use of the apparatus will be essential.

In preparing the above, reference has been made to all periodicals and scientific works accessible at the Naval Academy, including the resources of the library and the exchanges of the Naval Institute. I am indebted to friends for assistance, and wish to express my obligations to Captain Selfridge for the references he has permitted to the records of the Torpedo Station, and to Lieut. Comd'r Jewell for the kind interest which led him to copy the data referred to as from the Torpedo Station, as well as for much information embodying the results of his observations in practical tests.

NAVAL INSTITUTE, WASHINGTON BRANCH,

OCTOBER 19, 1882,

COMMANDER J. R. BARTLETT, U. S. N., in the Chair.

A U-BOW SECTION AND A LONG BUTTOCK LINE.

By LIEUTENANT SEATON SCHROEDER, U. S. N.

In the title of this paper are announced the two salient features of a form of immersed body which I have devised, and which, I think, will experience the least resistance when propelled through water. I am compelled to add, however, that since perfecting my course of reasoning and finally reaching the conclusions embodied in this design, I have suddenly learned that some one else produced a shape similar in general features some time ago without my knowledge. While deploring the loss of much claim to originality, I am glad to find great corroboration of the correctness of my views. Having reached practically the same conclusions by a wholly independent course of reasoning, I feel doubly confident in the value of this model; and, as it is apparently not very generally known, I have thought it well worth while, with the consent of the Committee, to lay my arguments before the Institute. My object now, however, is not to place on record a design, in the general conception of which I have been forestalled, so much as to elicit a discussion that will probably be of interest to all, and of benefit at least to myself. With this in view, I lay before you the gradual development of my ideas, as in that way the various special points may be best noted and discussed.

I will begin by saying that last winter while surveying in the Gulf of Samaná, my attention was attracted several times to certain phenomena connected with the resistance of bodies. On the first occasion I was standing on a beach in a sheltered inlet and my boat was coming for me. I was about a foot from the water's edge, and the boat grounded right abreast of me, about five feet off. She had hardly

touched when I became aware that the water had washed up over my ankles. Remembering this the next time I landed on a beach, I jumped up the moment the boat grounded, and looking forward could see the wave roll on and wash up on the shore. Pretending not to be satisfied with that landing, I backed off some distance, told the crew to "give way strong," and steered for a shoaler place, grounding about twenty-five feet from the beach. Looking forward again, I could see the wave travel onward, and finally make a sensible swash on the sand in spite of the retardation necessarily caused by the increasing shallowness. There was nothing new in all this. What I saw was simply the carrier-wave, or wave of translation, that the late Mr. J. Scott Russell followed on horseback up a canal, and the study of which paved the way to his celebrated wave-line theory. But it interested me very much and set me involuntarily thinking about the causes of resistance of ships. Unfortunately being rather steadily at work from daylight until dark, I had no time for experiments down there, nor even for thinking of the matter much. But when I was detached from the Despatch on the completion of the survey, a relaxation of that arduous duty gave me an opportunity to gather and formulate my thoughts as follows.

When a body advances through water at the surface, the particles acted upon must escape by going either under it, or around it, or both, according to the shape of the body. The question is, in which direction do they experience least resistance in effecting their escape? The answer to this question indicates, of course, the proper shape to be given the displacing body. The force that compels them to move is the pressure acting normally to the surface of the advancing plane. Supposing this plane to be normal to the surface of the water, but advancing obliquely, the pressure may be resolved into two horizontal components, of which one pushes the water aside, and one pushes it ahead. However small be the angle of the plane with the line of advance, or, in other words, however fine be the entrance, there will always be a small component pushing straight ahead. This must always create a wave, because the water being forced ahead, at and below the surface, creates a pressure which is transmitted onward until it is gradually relieved by the water heaping itself up in the shape of a wave. That the continuance of this wave, once formed, needs little exercise of power is well proven by the fact of Mr. Russell having been able to follow it for so many miles. It is also verified at sea, where we all know that the waves continue to surge on long

after the impelling power is annulled; in fact we often see a long swell when we do not feel the wind that caused it. Were the water perfectly fluid, of course, it would keep on forever; to make up for the degradation of the wave caused by the imperfect fluidity is a part of what calls for the continued application of power. In truth, if the water were perfectly fluid, probably no wave would be formed.

So much for the action of a plane inclined to the line of advance, but normal to the surface of the water, where the whole pressure is horizontal and relief is quickly effected by the prompt formation of a wave. Now let us take the case of an advancing plane not normal to the surface of the water, but inclined to it. As before noted the pressure acts normally to the surface of the plane. This force, resolved into its components, presses the particles of water forward and downward, the proportion of downward thrust increasing with the cosine of the angle of the plane with the horizontal. The particles that are pressed downward compel other particles to make way for them, water being practically incompressible. These other particles have to escape laterally and onward, and the pressure is deflected and finally transmitted upward to the surface where alone it can be relieved. The distance at which it would finally reach the surface depends upon the angle of the plane with the horizontal, and is probably also affected somewhat by the depth of water. This inclined plane corresponds with the shape of the bows of a vessel of the usual design; the pressure under the bows acts partly downward, and not being relieved until the wave at the surface is formed some distance ahead, the resistance must be greater than if the pressure were horizontal and quickly relieved.

Owing to the skew surface presented by a vessel's bows, this pressure and consequent wave is sent off in all directions from right ahead to abeam. Down in the Gulf of Samaná my attention was drawn also to this. I was running up a small stream in a Herreschoff launch, making about five knots. The width of the stream was a little more than the length of the boat, and we were in mid-channel. At a constantly moving point on either bank, if anything a little ahead of abreast the stem, a wave-hollow was formed, followed by a corresponding crest, the disturbance apparently ending after the passage of the crest. It was a very striking phenomenon, for the hollow was very steep and its passage made the stones and oysters rattle noisily over each other among the roots of the mangroves, and all without apparent cause. The hollow must have been preceded by an elevation

of the surface of the water, but that extended over such an area that I could not make sure of seeing it. The entire system seemed wholly independent of the immediate diverging waves of the bow, and I concluded that the leading swell must have been caused by the downward pressure under the curve of the bow expending itself in that way. In the open bay I never detected this hollow, though I think its forerunning long swell must have been present. The shelving bank, I presume, contracted the space in which the phenomenon was completed, thus producing a short, steep hollow in place of a long unnoticeable depression. From this I incline to augur that the advantages of a U-section will be more pronounced in shallow than in deep water.

The effect of this downward pressure may be put in another way. Action and reaction being equal and in opposite directions, the components of the resistance of the water to the pressure of the bow tend, one to push the vessel back, and the other to lift her. We are, therefore, while furnishing power to drive the vessel ahead, using a portion of that power in creating a pressure tending to raise the vessel.

It appears to me conclusive, then, that the water should be forced away laterally, and not downward in the slightest degree. In other words, the bow of the vessel should be normal to the surface of the water. Having decided upon the shape of the leading water-line forward, the others would follow it closely. The last one or two, near the keel, will be modified a little by the buttock lines, which I will come to shortly, and therefore should not be run in until later.

In this way it will be seen that a marked U-section will be generated forward in place of the V more commonly seen. In many works on naval architecture we see a general warning to beginners and amateurs not to make the forward lines full above at the cost of fineness below, but the authors do not recommend a *bona fide* U-section. I am happy, however, to be able to quote support from a paper contributed by Mr. R. E. Froude to Vol. XXII, Transactions of the Institution of Naval Architects. That eminent authority, in summing up, says: "It is worth noticing that the experiments at Torquay (carried on by his father some years before) have shown that, as a rule, moderately U-shaped sections are good for the fore body, and comparatively V-shaped sections for the after body." I am only sorry that Mr. Froude used the words "moderately U-shaped," for that does not encourage me as I would like to be encouraged by so

thorough an investigator. In the study of such interesting papers as the one referred to, I realize that my reasoning must appear crude; but I hope it is sound, nevertheless, and I prefer to give the reasons pure and simple that led to my design, rather than enrich my paper with elaborate quoted arguments which may sustain, but did not lead to, my theory.

So far, I believe, few vessels have been shaped as I propose, forward. The Alarm is one instance, but whether her U-section is a consequence of the enormous underwater snout, or made designedly to decrease her resistance, I cannot say. I deem it highly desirable that experiments should be made to ascertain her net resistance. She is said to be very slow now, but that, I imagine, is principally to be laid to the application of her motive power.

I apprehend that it may be objected that the wetted surface and consequent skin-resistance will be increased by the shape I propose. That is admitted, but I will advance two arguments to show that the advantages much more than outweigh that fault.

1st. The skin resistance, at low speeds, constitutes very nearly the whole resistance offered, fully 90 per cent. for a fair shape. Professor Rankine assumed that it constituted the whole at all ordinary speeds, and based his formula upon the assumption. That formula holds good within a fair approximation for such speeds as were common at the time of his announcing it, and for such speeds the resistance does vary as very nearly the square of the speed. But as the velocity increases, the resistance begins to increase in a higher ratio; owing to the wave-making factor. Some curious instances of the subordinate part borne by skin-friction at high speeds were furnished by the performance of some models on which the late Mr. Froude experimented some years ago. Even in the exquisitely shaped Iris, the resistance varies as very nearly the cube of her full speed, while at 12 knots it varies as only the square. Therefore by diminishing as much as possible that wave-making factor we create favorable conditions for high speed, which may perhaps be less marked at lower rates when the friction constitutes nearly the whole of the resistance.

2d. The U-section has the advantage of giving a greater displacement to the fore-body and to the vessel. This increase of size may be utilized by increasing the weight and power of the engines; or the other dimensions of the vessel may be correspondingly reduced, thus reducing the displacement and probably the immersed surface to that originally intended.

One advantage of the increased displacement being forward is in enabling the vessel to carry heavy guns there without straining the structure. I hope I will not be understood as desiring to throw weight in the end of a vessel. On the contrary, as may be seen in my plans, I like a hollow entrance, with which the centre of displacement of the fore-body is brought aft; and I would bring the weights aft with it. The increase of buoyancy brought about by the U-section would act most favorably for carrying guns near the foremast, in French half-turrets protruding sponson-fashion, which I deem the best arrangement that has yet been devised.

Above the water-line the bows of a vessel having a U-section may be continued straight up or flared out, or tumbled home; unless the lines forward are very sharp, the latter will naturally be brought about to a certain extent in a vessel with a slightly protruding ram-bow, which all fighting ships should have. In a merchantman with a straight stem, it would be best to carry the bow section line nearly straight up, with perhaps a slight flare at the deck, high out of water, to give more room for working the anchors, stowing the head-sails, etc.

In shaping the after-body I am guided wholly by the fact, which to me seems incontrovertible, that the lower and greater part of the void constantly being made by the forward motion of the ship is filled from beneath. For every foot of depth below the surface there is an increase of pressure of $62\frac{1}{2}$ pounds per square foot,—in fresh water. In salt water it is about 64 pounds. At a depth of 20 feet this pressure amounts to 1280 pounds, exerted equally in all directions, and the water, whenever there is an opening for it, is forced in the direction of least resistance. Professor Rankine sustains this, and says that in well-shaped vessels the paths of the particles of water approximate to the lines of shortest distance, such as are followed by straight strakes of planking when bent to fit the curve of the hull. It is evident that in vessels having the usual flatness of floor at the -⊕- the lines of shortest distance will be in a vertical plane parallel to the middle plane. Where there is a considerable dead-rise, the motion of the particles of water will be partly upward and partly athwart; but there will always be an upward component, except close to the load-line. Here the water rushes in laterally, the point where the lateral direction of the flow supersedes the vertical varying of course with the shape of the run. With tolerably full lines near the surface, which are generally necessary for several reasons, the upward flow must continue to be the greater source of supply.

In the course of recent promiscuous reading I have seen a very curious exemplification of the truth of my basis, that a void in water near the surface is mainly filled from underneath. When the twin-ship Castalia was under consideration in England, it was thought that the water would be carried away by the paddle-wheels between the two hulls faster than it would flow in, and that a hollow would be formed just forward of the wheels, it being supposed that the water would flow in at one end of the channel as it was driven out at the other.* But one day when her engines were started for trial in the Victoria Docks, her bows being against a jetty, every one was very much astonished to see chips of wood floating perfectly motionless between the forward parts of the two hulls, while between the after parts the water was racing like a millstream from the paddles. The next day several gentlemen got into a boat between the hulls forward to examine into the matter. Among them was Mr. Mackrow, the designer of the vessel, and to whose paper in Vol. XX, Transactions Institution of Naval Architects, I am indebted for these facts. These gentlemen naturally provided a strong painter for their boat, but found they had no need of it, for while the engines were going at full speed, and the water was being driven aft from the paddles at the rate of about 20 feet a second, the water forward of the wheels was practically motionless up to the very point where the floats struck it. A bit of wood was pushed up to within an inch of the floats, and instead of being drawn in and under, it returned to the boat. The fact of its being impelled forward is accounted for by the known existence of a wave formed by the action of the paddle; men that have fallen overboard have been saved in the same way; but if the water were sucked in from forward to replace that which was driven aft in such volumes, that wave could not have saved the chip. As the water therefore did not flow in from forward, and could not possibly flow in from aft, it seems evident that the only source of supply was from underneath, the water sinking down from the surface outside to fill up the vacant space. Mr. Mackrow immediately reasoned out, therefore, that as the paddles scooped out the water to a depth varying from 0 at the surface to 3 feet 8 inches, which was the extreme dip of the wheels, so the particles of water from below thrust themselves up-

* In case any one present should happen not to be familiar with the construction of this vessel, I may say that the Castalia had two hulls 26 feet apart, connected by a superstructure, and was propelled by two large paddle-wheels in line between the hulls, 22 feet in diameter and 10 feet broad.

wards at a velocity due to the pressures at the various depths, or from nothing at the surface to 228 pounds per square foot at the lowest depth. I need not say that to me this reasoning appears absolutely correct, tallying as it does with my own views.

In the case of the stream under a vessel's run, as the water sinks down from the surface in consequence of its weight forcing the water near the ship to rise along the lines of shortest distance, there will be perhaps a slight lateral set; but this must be imperceptible near the middle-line. At a distance of 10 feet from the keel and 20 feet from the ship's side it is probably immaterial; at 20 feet from the keel and 10 feet from the side it must be quite sensible.

To minimize the resistance experienced by a vessel in motion, it is essential that the forward pressure on the run should be decreased as little as possible. For this it is necessary that the water should flow most freely to that part, which can best be accomplished by giving the same shape to the run that free water would assume in rising to fill the space vacated by the advancing vessel. It is easy to conceive that the shape of the continually advancing surface of water under the run should be that of the front face of a sea-wave, as advanced by Mr. Scott Russell; and the trochoidal theory in all probability does closely approximate to the phenomena of deep-sea waves. We cannot go far wrong, then, in accepting, as a basis for argument, Mr. Russell's dictum that the buttock-line should be a trochoidal curve. But I feel inclined to think that there is reason to disagree with that great architect in his formation of that trochoid. The wave-method of construction gives the principle that there is a fixed proportion between the intended speed and the length of run, the latter being determined by, although somewhat greater than, the length of the front face of a wave of the second order travelling at that speed. To my mind there is another element to be considered, viz. the height of the wave. Long series of observations, made principally by officers of the French navy, show that the average ratio of length to height of deep-sea waves is 25; for a wave 100 to 200 feet long the mean ratio is 20. Mr. Russell gives the length of run necessary to prevent undue resistance at a speed of twenty statute miles as 120 feet, which considerably exceeds the length of the front face of a wave travelling at that rate. In a vessel such as the Iris, intended to make over twenty statute miles an hour, the draught, or height of wave thus to be formed under the run, is 22 feet, or say 21 without the keel, and it seems clear to me that the wave 240 feet long, the front face of which has to fill the void constantly being

made, cannot completely fill it to that height, its own natural height being only about twelve feet. To fill it properly would require a wave 420 feet long, or a length of run of 210 feet. The length of the Iris is 300 feet between perpendiculars, but her lines are so fine that I doubt if the length on the water-line of the first bow-and-buttock is much over 210 feet; therefore the buttock-line should begin to rise from the very bows.

Even supposing that the shape naturally assumed by the water rising under the run be not exactly that of a sea wave, or that we do not succeed perfectly in shaping the run to correspond, it still seems reasonable that the greater the length of the advancing surface of water, the greater will be its height or its ability to more than fill in the void to the required height; and that is what I deem essential to decrease to a minimum the increase of resistance due to the lack of water pressure on the run.

In vessels of such proportions as are ordinarily required in fighting ships, the buttock-line must be given the greatest length possible; and in some the proper length may not be obtainable. For instance, a vessel of twenty feet draught, excluding the keel, should have a length on the main buttock-line of at least 200 feet to ensure filling the void. That is the half-length of a wave travelling at the rate of about twenty-seven knots an hour, so it is probable that there would be no abnormal decrease of pressure under the stern up to a speed of over twenty knots, if we ignore the effect of the propeller.

At first I would have liked to make the buttock-line a trochoid of the given length and height, but in practice this is not feasible. The U-shaped bow-section makes the leading forward longitudinal section-line run vertical, turning and immediately merging into the long buttock-line away forward and on the level of the top of the keel. In consequence of the immediate rising of this line, the floor, which is flat forward, will gradually rise also, and if the buttock-line were a trochoid the rise would be too rapid, and would make the vessel too lean amidships and aft. Particularly would this fault need correction in unarmored naval vessels, as the imperative necessity of keeping the tops of their boilers below the water-line will always impose restrictions on the amount of dead rise at the midship section. These conflicting requirements can be reconciled, however, without prejudice to fairness of lines or freedom of water-flow. To flatten the curve properly, I propose to make it approximate to the leading part of a trochoid of much greater length and height. This curve, where it cuts the water-line, will not have the slight hollow that characterizes

the upper part of a wave-front; but that is certainly of no material consequence, as the lateral flow will assert itself so near the surface and wholly modify the conditions.

Nothing is lost by flattening the curve in this way, as the new shape will correspond to that of the leading portion of a wave-profile of much greater velocity, which should therefore have a tendency to fill the void more completely than a wave whose speed only slightly exceeds that of the ship. This quality is highly desirable, because we have not simply to fill the space vacated by the moving vessel, but in addition to provide for the race toward the propeller. The late Mr. Froude found that in well-shaped vessels the "augment of resistance" by the induced negative pressure under the stern consequent upon the thrust of the screw is about forty per cent. of the net resistance. As about thirty-nine per cent. of the I. H. P. is usefully employed in overcoming the net resistance, it follows that fifteen or sixteen per cent. of the I. H. P. in a single-screw ship is swallowed up by an augment of resistance created by its own self-application. The more freely the water is allowed to flow in under the run and to the screw, the less should be that augment; and by having what I call a vertical run properly shaped and equal to nearly the length of the ship, and by having a fairly long and fine horizontal run, it is to be hoped that enormous figure may be reduced. For myself I hope to see the day when no ship of war of moderate or large size, and no merchantman of large size, will be propelled by a single screw. This question, however, is foreign to the matter in hand, and is too important to be lightly discussed.

In shaping the second buttock-line,* more latitude is allowable than in the leading one, especially aft. Being farther from the centre line, the filling of the void on its plane will be less dependent upon the upward flow, as the lateral pressure will begin to be more felt. For a naval vessel intended for ordinary service I should complete the midship section after the leading buttock-line is drawn, and make the second buttock conform to it and the load-line. Running in the rest of the hull will be easy enough; in the after-body, as in the fore-body, there will be four points predetermined for each water-line, viz. the intersections of the horizontal plane with the midship section, the two buttock or bow section lines, and the stern-post or stem.

I put the greatest beam at the middle of the length. This is in accordance with what I believe is the ordinary practice now of making

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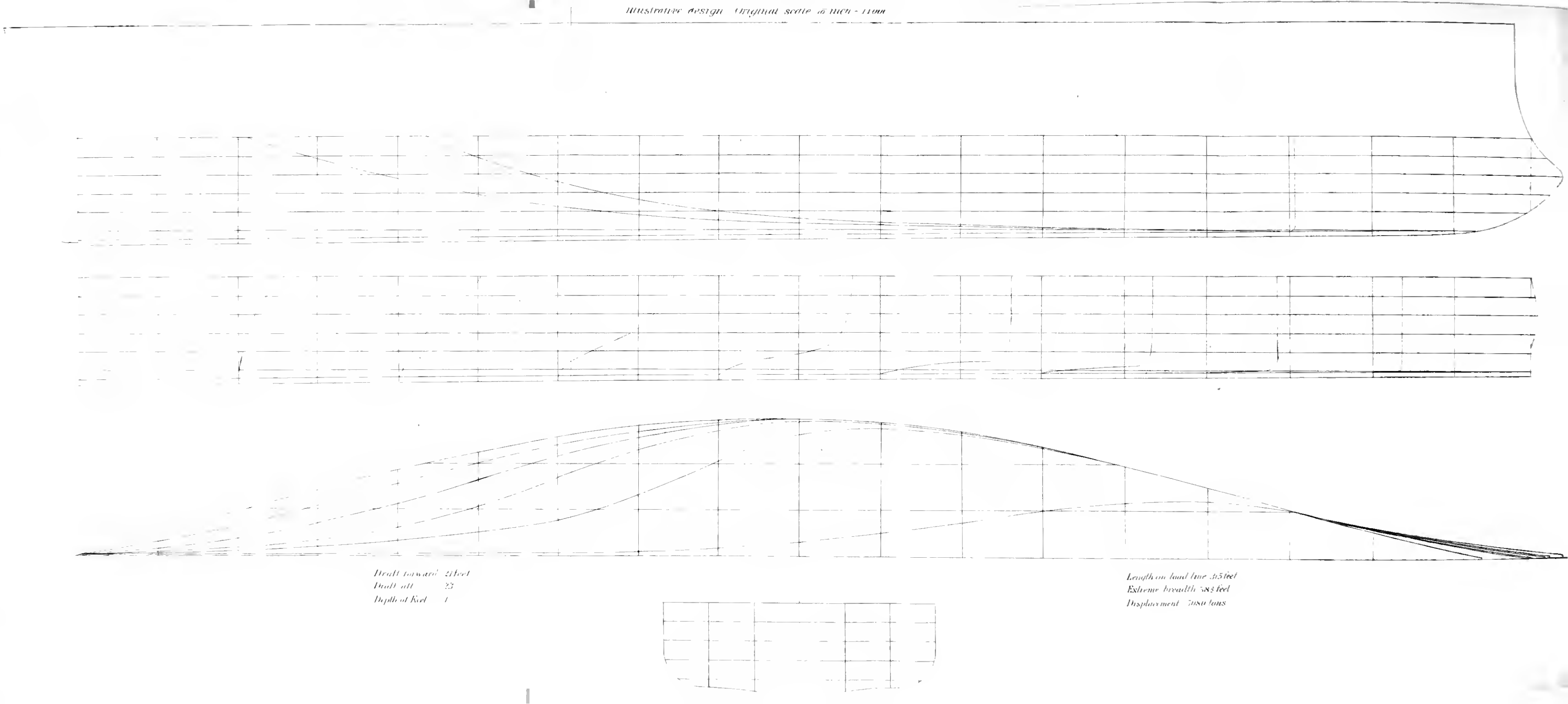
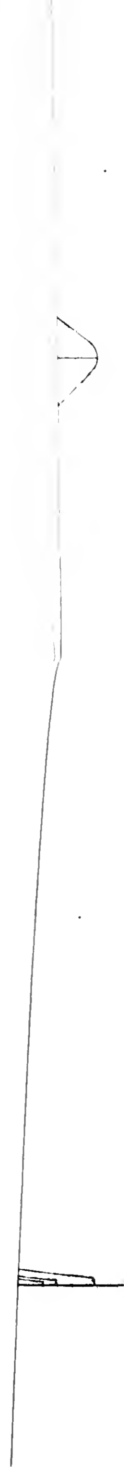

Illustrative design Original scale
Draft forward 21 feet
Draft aft 23
Depth of Keel 1
Length on load line 315 feet
Extreme breadth 58½ feet
Displacement 7080 tons



the length of the run equal to that of the entrance. My reason for giving a longer run in horizontal lines than is prescribed by Mr. Russell is, that in giving two-thirds of the entrance as the proper proportion, I believe he had regard only to what he deemed necessary for a vessel being propelled through the water without any disturbing influence at the stern. Moreover, he was guided by the same principles as in designing the buttock-line, namely, by the desirability of having the water-lines fit the front slope of a sea-wave; which principle I am not prepared to accept, even in my modified form, when applied to the case of water moving laterally.

The plans that accompany this paper have been drawn simply to illustrate the two peculiar features that I propose, and I hope they will be regarded in that light. I took great pains with them of course, using a magnifying glass to make some of the measurements, and I believe the displacements to be within a few tons of the truth; but the coefficient of fineness is smaller than I deem desirable. The proportion of length to breadth is such as I should recommend for an unarmored naval vessel, but the horizontal lines are much finer than need be. By *fulling* the load-line aft a little it is evident that the after-body would be made much more buoyant, and the total displacement considerably increased without prejudice to the easy flow of water under the run, as the buttock-line would be proportionately lengthened. The lines forward are also those of a despatch-boat rather than a fighting ship, and hardly afford sufficient support for the ram; if made slightly less fine, they would, in consequence of the U-section, add very greatly to the displacement. As a matter of fact, with the same dimensions this model has a greater displacement that the usual shape, with equally fine lines.

The buttock-lines are drawn on curves sufficiently flattened to keep the tops of the boilers three to four feet below the water-line; while the beam of the vessel will permit of giving them considerable lateral coal-protection.

I have now laid before you the conclusions that I have reached. and the train of thought that guided me to that end. It only remains for me to repeat my premise—that after all my labor it appears that some one else devised a practically similar shape some years ago. The gentleman in whose wake I have thus unwittingly followed is a constructor in the Brazilian navy.

It was not until about a month after I had formulated my thoughts as above, that I happened to run across a small pamphlet containing a description, written by Captain Luiz Philippe de Saldanha, of the

Brazilian navy, of "A novel formation of the bottom of ships and vessels, proposed by Trajano A. de Carvalho, Brazilian Naval Architect." The following is the general description of this design in the words of Captain Saldanha:

"According to this invention the exterior surface of the immersed body of the vessel is composed of two continuous surfaces, one being without twist, or nearly so, and the other a twisted surface. The former of these surfaces is generated by a straight or nearly straight, and vertical or nearly vertical line passing from the stem to near or beyond the middle of the length, and contains the load water-line throughout the fore-body; which line may at the fore-part of the ship be more or less concave if desired, and this surface being practically without twist, all the other horizontal sections, so far as they are contained in it, will be of the same shape as the load water-line, or nearly so. The other or the twisted surface commences in a flat floor or in a nearly flat floor, at the fore-foot, and becomes more and more nearly vertical from this flat to the stern-post. The generating line of this twisted surface may differ from a straight line and may also change its form, if desired, as it travels aft. The line of junction of the two component surfaces need not be allowed to show as the edge of a sharp angle, but may be rounded off so that the two surfaces referred to be like fashioned into each other."

It is evident that the two generating lines spoken of may be so handled as to produce almost any shape of run; but the two main features of this design are undoubtedly the same as those that I have proposed, viz. a U-section forward, and a vertical run equal to the length of the ship on the plane of the longitudinal section. I do not know what course of reasoning led Señor Trajano to think of this shape; nor do I know on what principle he constructs his buttock lines. In truth I am led to believe that he does not advocate any particular curve. But the general result is much the same, and the performances of the vessels built in Brazil according to his design have been found highly satisfactory; remarkable sea qualities and buoyancy were developed, and all claims substantiated of high speed with the most moderate proportions of length to breadth, increased speed for the same power, increased displacement on the same dimensions with finer lines.

The late Mr. Froude also experimented with the model in the British Admiralty tank, and the results of the trials are briefly summed up in the following letter from Mr. Barnaby to Señor Trajano:

ADMIRALTY, *29th December*, 1875.

My Dear Sir:—Mr. Froude has been good enough to subject to trial at Torquay, by my desire, two models of what are known as the Rendel Gunboats, upon the scale of three-quarters of an inch to a foot. One of these was of the proportions and form adopted in all these boats hitherto built in England, whether for the Admiralty or for foreign powers; the other was of the proportions and form given in your plan which you gave to me.

Mr. Froude's experiments gave the following result:

	Admiralty Design.	Señor Carvalho's Design.
Displacement, or total weight, . . .	349 tons.	379 tons.
Power required to drive boat 9 knots,	330 horses.	220 horses.
Ditto, 10 knots, ...	575 "	425 "
Length of boat, ...	110 feet.	110 feet.
Draught of water, ...	5 ft. 10 in.	5 ft. 10 in.
Breadth, ...	26 feet.	34 feet.

I must confess that although I was very pleased with your proposed form, I was not prepared to receive such an extremely favorable report. In our new vessels of this class, we shall be obliged in view of these results to alter our plans, and I will communicate further with you in the matter.

With my sincere congratulations I am, my dear sir, yours faithfully,

NATH. BARNABY.

SR. TRAJANO A. DE CARVALHO.

Now, gentlemen, I think that report shows that there is something in this model. A vessel so designed, with the same length and draught of water, but with eight feet, or about one-third more beam, and thirty tons, or about one-twelfth greater displacement, requires, to drive her nine knots, one-third less power than the usual Admiralty design. In addition to this we learn from Brazil that vessels of 2000 tons and over have been built of this shape and found highly successful in point of speed, cargo capacity and passenger accommodation. I am naturally a little surprised that it is not more generally known, and I fancy that will be advanced in criticism. But while the more or less extensive adoption of an idea is very often a fair test of its worth, it frequently happens that prejudice unconsciously blinds people to the actual merits of an innovation. There are also other influences that tend to interfere with the rapid propagation of a possibly useful invention. If a private shipbuilder were to build a vessel after a new design, and it were to prove a failure, he would probably not publish to the world that he had made a blunder; if, on the other hand, he found that on the same displacement, and with

the same power, he realized a greater speed than his rival neighbor, he would be very apt to pocket the increased annual profits without saying much.

It may be that the design is more generally known than I am aware of. Ignorance in such matters is one of the disadvantages under which amateurs like myself must labor. I know that a few gunboats for river service were built in England with that form. I have also heard that a vessel was built somewhat after this design four or five years ago by Mr. John Roach for the Cromwell line. It is possible that there may be many others. I shall be very glad to hear that such is the case. My interest in the matter now is mainly a desire to advance what I consider a good model, and to foster discussion on the various points presented.

Congress has given us money to build two new ships. Perhaps we may hope for more. In these two we are taking a new departure in the question of material. Does it not behove us at the same time to watch closely for a successful departure in the matter of shape? In putting this question I do not wish to appear as throwing discredit on the models of our past and present ships. Far from it. I believe them to be as good as any up to the time they were made. The net resistance of our ships, such as is experienced when under sail, must be as little as that of any men-of-war in the world, because as a rule they cannot be beaten under sail. In one vessel, the Benicia, under close-reefed fore and main topsails, with the propeller triced up out of the water, I have seen sixteen knots run off the reel about two seconds before the glass was out. I have seen another, the Swatara, making twelve knots under topgallant sails, with the wind abeam, the screw being uncoupled and revolving. And those vessels stay and wear well, and ride the seas like ducks. The Constellation and the four frigates are also noted sailers. Their models therefore must be good. But improvement is never impossible, and I should like very much to have it put to trial whether or not increased speed for the same displacement and power is not to be produced by this shape of underwater body.

Of the two innovations proposed, I attach the greater importance to the length of buttock-line or vertical run; but that is impossible without the U-section, which alone enables us to get that length. The two, therefore, go hand in hand together, and produce a shape that recommends itself most strongly to my limited knowledge of the subject.

NAVAL INSTITUTE, NEW YORK BRANCH.

OCTOBER 3, 1882.

COMMODORE JOHN H. UPSHUR, U. S. N., in the Chair.

THE FRYER BUOYANT PROPELLER.

BY LIEUT. W. H. JAQUES, U. S. N.

Lord Bacon said "There are three things which make a nation great and prosperous—a fertile soil, busy workshops, and easy conveyance of men and things from place to place." We can feed the world, our manufactures are unsurpassed, and our means of transit by land and inland water are wonders of speed and elegance; if to these we can add the swiftest and most acceptable ocean steamship, we will have perfected the problem of greatness and prosperity. The unlimited applications of electricity and the surprising rapidity of their development have given incentive to inventors and theorists to perfect their plans, in spite of the ridicule and contempt hurled upon their enthusiastic and devoted labor by thoughtless and ignorant people. Again, men must have a change; enterprise implies a change. Such incentive and the appetite for fast and comfortable ships are spurring to a solution of these problems and the satisfaction of these demands, every one who knows the signification of the word ship and the requirements of a modern steamer.

The wonderful success of the Guion steamer Alaska is pointing surely in the right direction. The September *Century*, in an article on "Ocean Steamships," said: "Thirty years ago sixteen days was a fair allowance for the passage between England and New York by steam. By gradual steps the point was reached when eleven days was the minimum, and this startled the world. In 1871 the Adriatic's best westward time was eight days, fourteen hours and

twenty minutes. It should be remembered that the westward passage is generally longer than in the other direction, owing to the westerly winds and the Gulf Stream. In 1877 the City of Berlin, of the Inman line, made the trip to Queenstown from New York in seven days, fourteen hours and twelve minutes, and in the same year the Britannic, of the White Star line, crossed from Queenstown in seven days, ten hours and fifty-three minutes. In 1879 a new rival appeared in this field, the Arizona, of the Guion line. This steamship made the eastward passage in 1880 in seven days, ten hours and forty-seven minutes, and in one trip in 1881 she lessened this time about three hours." But all these remarkable runs have been surpassed by another Guion steamer, the Alaska. In June, 1882, she ran the eastward trip in six days and twenty-two hours actual time, and in September decreased this time by three hours; even the limit of *her* speed has not yet been reached, and we are no longer surprised when we read, after each new passage, that she has beaten "her best previous time."

But the proposed steamship, the "Fryer Buoyant Propeller" (Plate A), a description of which I purpose in this paper to offer for your discussion, is such a strange-looking craft that one would not be surprised if it excited simply ridicule and contempt instead of the careful consideration its invention deserves. Where would we be to-day had we allowed derision and insult to stop the progress of sea communication, lest by the construction of some better-adapted sea-wagon we might bring mockery about our ears? Probably in the Egyptian acantha bark covered with papyrus, in galleys fashioned like those of ancient Greece, or in the stately Genoese carrack. When Papin built his steamer and navigated it on the Fulda, the scorn and raillery did not deter him from attempting to reach London in her; only her destruction by the superstitious boatmen of Munden prevented. Because Rumsey, after a long struggle, was doomed to disappointment, his young American friend, Robert Fulton, was not frightened from giving us the first successful and useful paddle-steamer, though he paled with rage at the jeers and taunts of the crowds who witnessed his first departure for Albany.

I know it is said, and supposed to be proved, that our successful ship of to-day is nearly a duplicate of the Ark; but let us not then be ridiculous in the extreme by condemning without reason or argument an invention which has already experimentally demonstrated its usefulness.

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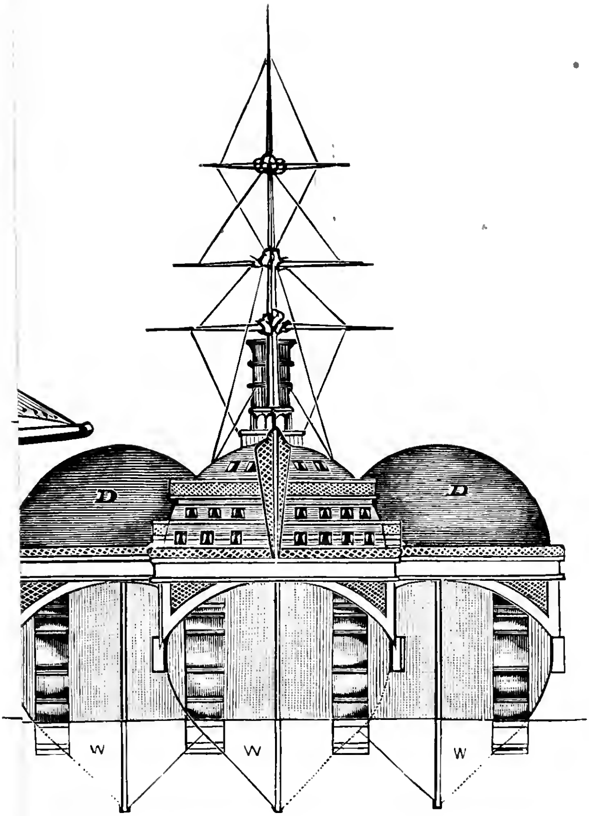

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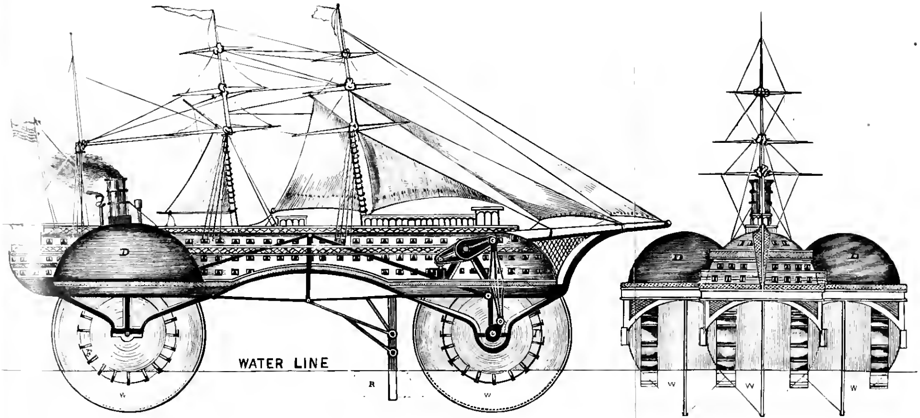

FRYER BUOYANT PROPELLER PLATE A

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Though outlined by the inventor, Mr. Robert M. Fryer, some twelve years ago, given severe labor, great concentration of thought, and studiously experimented with by him, he has not arrogantly attributed to his own genius the absolute conception of the idea, but rather the development and application of ideas suggested centuries ago. But to whom should be given the honor if not to him who endows the world with practical evidence of his genius and usefulness? Because the possibilities of steam were known to the ancients, did De Garay, Papin, Hulls, Fitch, Stevens, and a host of others, lose any of the glory due them?

Description.

The "Fryer Buoyant Propeller" is a three-wheel wagon or tricycle. The three wheels are hollow spheroids, holding the bed of the car or ship above and entirely out of the reach of waves. These spheroids are not only the buoyant and supporting parts, but by their triangular position insure stability, and by their revolution provide the motive power, the rows of flanges or buckets on both sides of each wheel catching the water-line like a finely feathered oar. Each spheroid is capable of independent rotation, assuring handiness and safety even without a rudder. A critical investigation of the strength and weight of materials and the weights to be carried to satisfy the demands of speed, security and comfort, has shown that the propellers will not be immersed more than one-sixth of their capacity, or, if required to rest upon land, that the weight will not be great enough to crush the wheels at the points of contact.

The plans for a vessel for ocean navigation to carry one thousand passengers and one hundred tons of mail and express matter, provide for three spheres of sixty feet in diameter, exclusive of keel or projection.

Each sphere is composed of plate steel 5-16 inch in thickness. This surrounds a secondary shell or sphere 59 feet in diameter, composed of plate steel 5-32 inch thick. The space between these spheres is partially occupied by a framework composed of sixty-four hollow steel girders, radiating from flanges located near the ends of the shafts, to which the above spheres are firmly fastened, thus making a lateral conductor to a point near the flanges for the discharge of any water that may accumulate between the two shells. (Plate B.)

The sphere is further divided by a disk (80) eighty feet in diameter, composed of plate steel 3-16 of an inch thick. Attached to this

division plate is the base of a double cone twenty feet in diameter at this point, while the smaller or opposite end of said cones, being ten feet in diameter, terminates at the flanges located at the ends of shafts as above stated.

Parallel with this cone and attached thereto to the division plate and to the inner of small shell are sixteen partitions each side of said division plate, composed of No. 17 steel plate.

The object of these partitions is twofold: First, to add strength to the spheres, and next to subdivide them. Each division is provided with an outlet at or near the flange, so that any water that may find its way into said compartments will flow down the inclined surface of the cone to the place of discharge when the compartment is above the centre of gravity. This, of course, is in case the sphere revolves slowly; when turning fast, centrifugal force will prevent water from leaking in, even though the shells are not absolutely tight.

The flanges above alluded to are each ten feet in diameter, having a hub of six feet in diameter by twelve inches long. The above-mentioned hub is made to act as a journal in case the main shaft should be broken or disabled. This shaft is steel, three feet in diameter at the ends or journals, and through the flanges to which it is attached; from these points, inside of flanges, it diminishes to two feet, and then tapers down to one foot to the centre of sphere, where it unites with the division plate by suitable flanges.

The sphere is provided on the periphery, in the plane of its rotation, with an annular keel or projectile protruding *ten feet* from the surface of the spheres, making the wheel at this point eighty feet in diameter. (Plate B.) From this place the projectile widens as it runs back towards the sphere, which it strikes at a distance of thirty-four feet on a direct line, thus uniting with the natural arch line of the sphere, at which point the paddles are located. These paddles (thirty-two in number) are placed on each side of the wheel, and are of strong wood or iron.

The projection above referred to is subdivided and supported by girders, resting at one end upon and fastened to the main sphere girders, and at the other end upon the division arch, which is thus strengthened to meet hard substances with which it may come in contact. Water which may leak into the compartments of the projectile is allowed to run off between the girders through openings provided for that purpose.

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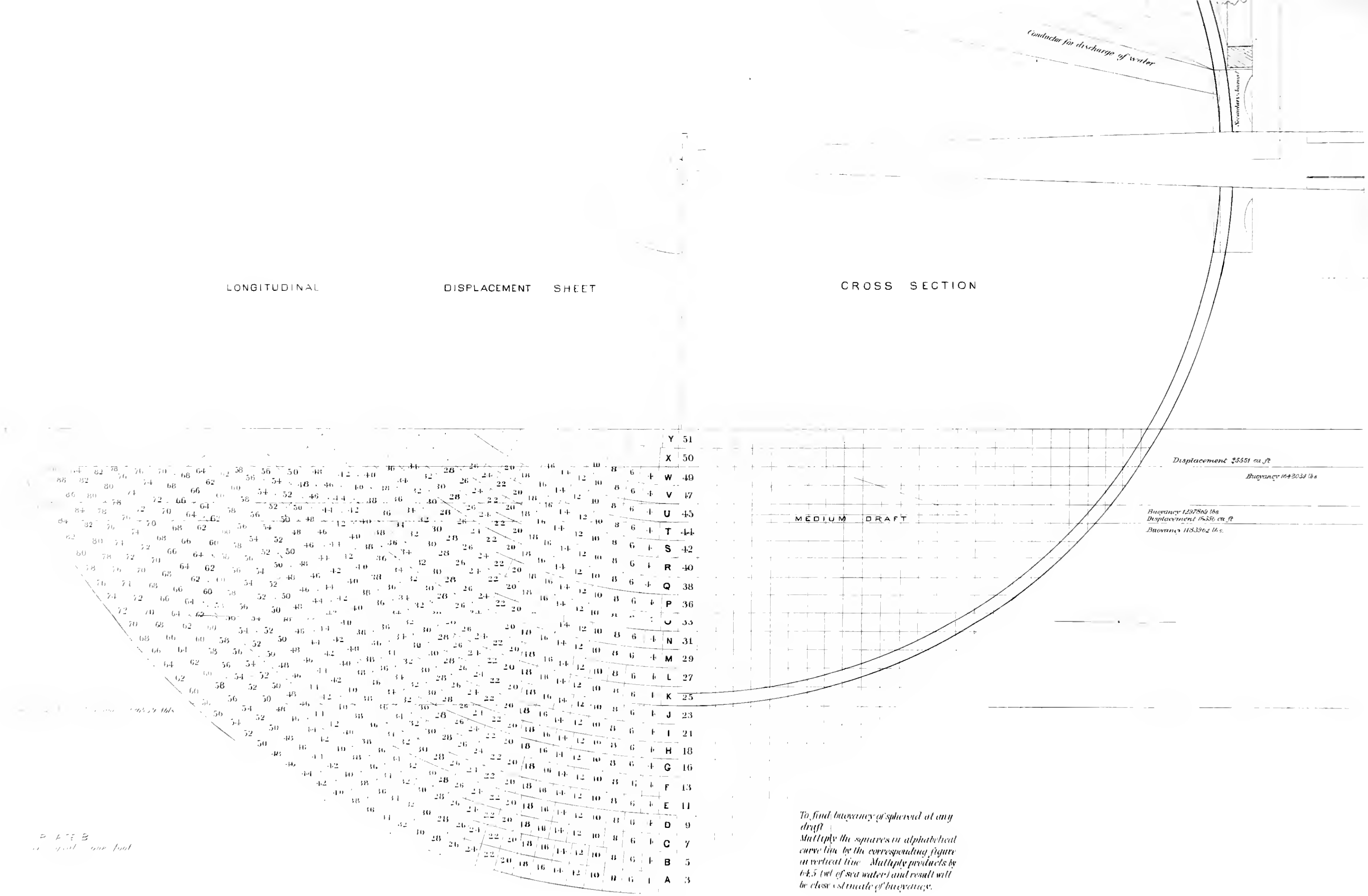
LONGITUDINAL DISPLACEMENT SHEET
CROSS SECTION
Conductor for discharge of water
MEDIUM DRAFT
Displacement 35551 cu ft
Buoyancy 1297869 lbs
Buoyancy 1183962 lbs
To find buoyancy of spheroid at any draft
Multiply the squares in alphabetical curve line by the corresponding figure in vertical line. Multiply products by 64.5 (wt of sea water) and result will be close estimate of buoyancy.

The main framework, which rests upon the six journals of the spheroidal wheels, is composed of steel truss braces, together with angle and channel plates uniting with the lower end of the main arch which forms the cover of the cabins, etc.

The arch is subdivided by steel plates and trusses into staterooms, halls and other apartments.

The spheres are housed in (above) with dome-like covers, composed of sixty-four girders, radiating from the top centre of main frame. Said girders are covered with steel plate.

DIMENSIONS.

Diameter of sphere	60 feet.
Diameter of sphere with projection	80 "
Length between centres	192 "
Width	84 "
Length over all	324 "
Width over all	150 "
Length of decks	288 "

The actual displacement of the three spheroids of eighty feet in diameter at a depth or draft of twenty-three feet is 2472 tons. This would place the axle centre seventeen feet above the water line, and the bottom of the superstructure some thirty feet above the water line, or clear of the waves in any weather at sea. With the fullest allowance of weight required for safety, the vessel loaded and ready for transatlantic voyage can be made to draw not more than twenty-one feet.

In conducting the experiments the first model was simply three hollow copper globes connected by axles, with a frame in the form of a tricycle, or one wheel or globe in front and two on a line behind. These globes were twelve inches in diameter, and were revolved by springs placed inside and wound up by keys. A weight of five pounds placed on the frame immersed the globes about two inches. When wound up, these globes would carry the frame and weight on the water in a tank, over rocks, running out of the water and up a board out of the tank; would turn in its own length by stopping one hind wheel; would run on the water after the force of the springs was too much spent to turn the wheels on the floor, and in every test showed no appreciable slippage, making the entire distance of the periphery length.

This small model was taken to the Harlem river, where it acted as in the tank, showing very slight effect of currents, waves or wind. Rigged with a small sail this model of the twelve-inch globes rode over chopping waves eight to fourteen inches high, with very slight oscillations amidships and without wetting the frame. This experiment was carefully made because the buoyant capacity of any form of wheel decreases so rapidly in proportion to its surface, as small dimensions are reached, that it was thought that a moderate-sized apparatus would not sustain the framework high enough above the surface of the water to avoid severe shocks and wetting. From the results of these experiments it was decided to build a larger model, and one was completed with globes six feet in diameter, or six times the diameter of the small one. (Plates C, D.) The six-foot globe model was fitted with an engine and boiler, which, with frame, deck, and other appliances, put a weight of about four thousand pounds on the three globes, immersing them nearly the same distance that five pounds did the one-foot globe; or globes six feet in diameter carried eight hundred times the weight carried by globes of one foot in diameter, with the same proportion of immersion. The steam model has been experimented with almost daily for four months, carrying two to twenty passengers, generally running up out of the water on a track to dry ways, after each trip. It also steamed across the land from the Harlem river to Spuyten Duyvil creek (nearly ¼ mile), and travelling to the water's edge, continued on over the surface of the water as rapidly and readily as it had travelled down hill. As to slippage, action against and with wind, tide, and over such waves and swells as occur in the Harlem at this point, the steam model has simply repeated the results of the smaller; as to speed, the larger naturally shows an increase over the smaller. The larger model has also demonstrated the perfect manner in which water from any leak or break in the globes is discharged by a half turn of the globe, without appreciably impeding the boat. The very slight strain on the framework, and its steadiness under every test, has been the marvel of every one of the many who have ridden on her deck.

The rudder was placed immediately behind the forward globe and readily controlled all movements of the tricycle.

If a careful investigation of the submitted plans and model experiments discover all the qualities of buoyancy, stability, handiness, durability, strength, speed, economy and sanitary excellence essential to a perfect ship, there remains but a practical test of a vessel of suit-

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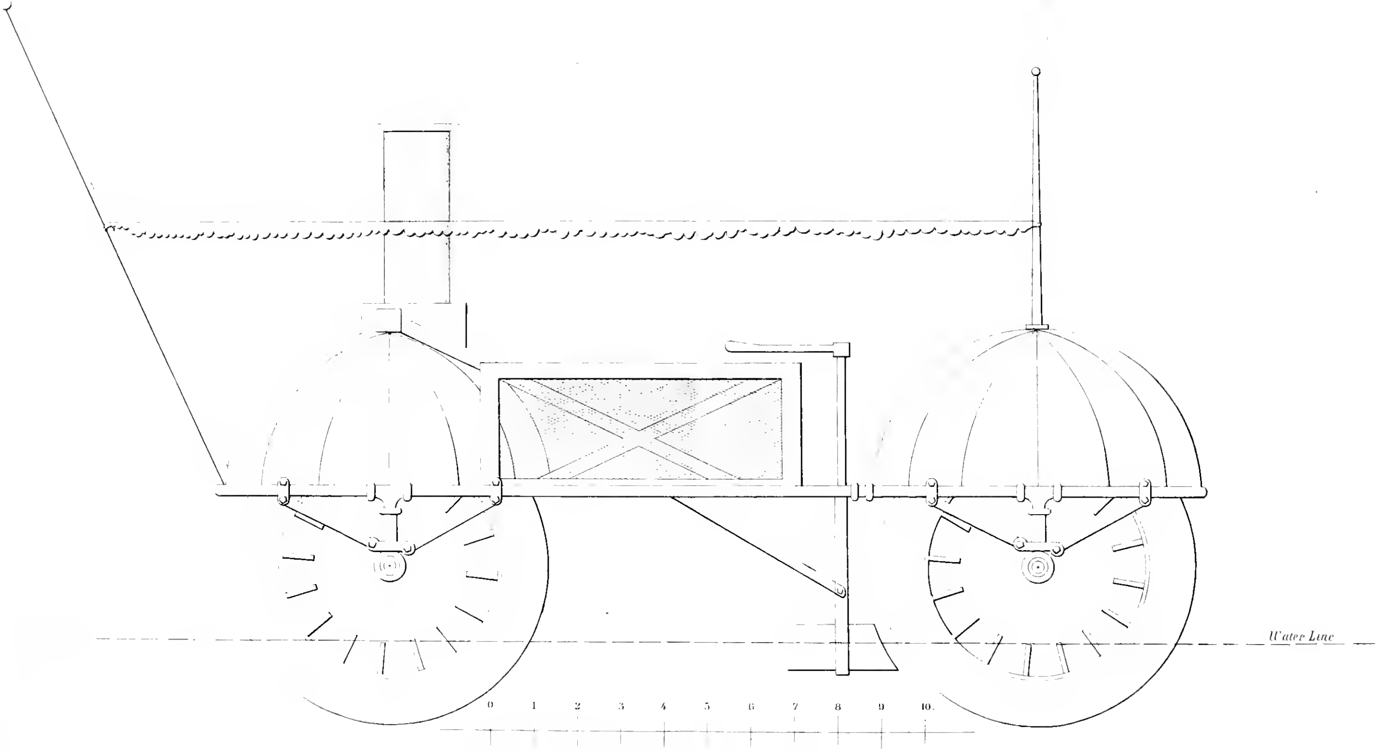
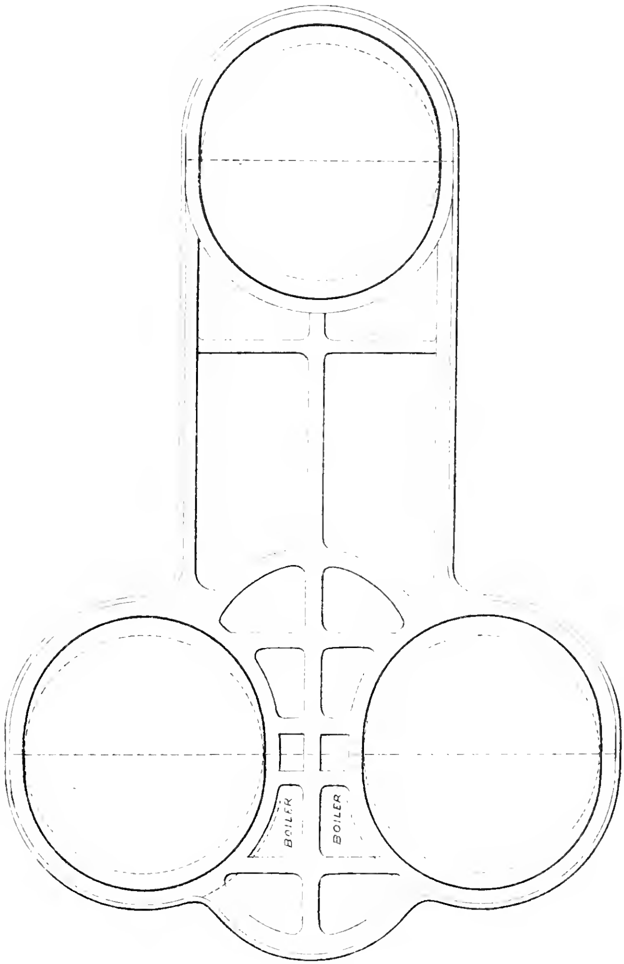


Scale of feet

Model of Fryer Buoyant Propeller



Fryer Buoyant Propeller

Top Plan of Model

PLATE, D.

0 2 4 6 8 10

Scale of feet.

I FRIEDENWALD, LITH BALTO

able size for actual service purposes, the Government encouraging the invention by contracting for one to meet certain requirements, the company taking the responsibility of risk of failure.

The oldest mariners, probably without knowledge of the cause, knew that the breadth of a vessel extended beyond a certain proportion helped to reduce her speed; that too much roundness caused their galleys to roll; that too little breadth of beam rendered their ships liable to be overset by any element natural or artificial. We are also told that the South Sea Islanders, equally aware of this last defect, either joined two vessels to each other, as we now do more scientifically and mechanically in the catamaran, or added such extraneous part as would give the required stability.

BUOYANCY. (Plate B.)

Contents of each spheroid	148.545 cubic feet
Weight of average sea water	64.5 lbs. per " foot
Buoyancy of each spheroid	4,790 tons
" " the three spheroids	14,370 "
Weight of vessel loaded	2,300 "
Reserve of buoyancy	12,070 "

Less than one-sixth of the buoyant capacity is needed to sustain this structure, even with the weight of material estimated for the above plans; and it has been admitted by skilful constructors that this weight can be greatly reduced and still meet all the requirements of strength. This large reserve of floating power, which has evidently suggested the name of the ship, does away with the necessity so often required to sacrifice strength and capacity in order to get the flat floor essential to buoyancy and speed. At the same time this reserve can effect no harm, owing to the triangular position of the spheroids.

In regard to the distribution of weight and buoyancy we usually find the weights of engines, boilers and coal concentrated at some part of the ship. The Fryer tripod rest, on three points of contact in tricycle form, will permit such distributions of these weights as to produce the minimum strain upon the midship body and a perfect equality of weight with buoyancy.

STABILITY.

A glance at the peculiar formation, the three points of contact and the apparent want of immersion, would naturally indicate marked poverty

of this important quality. But we must remember that "mere immersion does not give stability"; also, that every vessel displaces a quantity of water equal to her weight, no matter what the form or whether constructed of one single or several connected bodies.

The situation of the three important points, centre of gravity, centre of displacement and the meta-centre, is such that instability can never result from the centre of weight overtaking the centre of buoyancy, or the meta-centre reaching or falling below the centre of gravity. When rolling and pitching the immersed surface of the steamer of to-day is not increased, but only altered, another position nearly similar in form receiving the upward pressure. The weights on the opposite end of a short lever constitute the only other force acting to restore equilibrium. The result is an equal transit on the opposite side of the axis, and a rolling and pitching approximating the perpetual motion so greatly coveted for some purposes, but *not* for ships. In any position of the Buoyant Propeller there will be the weight of one or two spheroids at the end of a long arm to counteract the wind and wave forces. Add to this the upward pressure caused by the increased immersion of the lee spheres or globes, and you will have an equality of powers producing the utmost stability and utter absence of sickness even in the roughest weather. The action of the models showed less oscillation than the ordinary boats of equal displacement. But this principle has been so thoroughly proved in practice, from the South Sea Islander's flying-proa, invented centuries ago, to the catamaran and outrigger of the present day, that I need give no further evidences of the stable qualities of the Fryer Buoyant Propeller.

Handiness.

The immense increase in ships in size and number, the frequent collisions, and the demand for rapid transfer of men and merchandise, call attention to the necessity of fine manœuvring endowments. Since sails are to be auxiliary, as they are in all our modern steamships, the principal working qualities required are those of going astern as readily as ahead, and turning quickly and accurately in as small space as possible under the action of steam, propeller and rudder, or other means.

The independent action of the spheroids and the successful experiments with the models fully satisfy these requirements, while the wheels also perform all the functions of a rudder in case of accident to that important member.

Durability.

With material selected from the best manufactured steel, with every factor and part of the ship within easy access and handy repair, the complete absence of those deleterious gases and corrosions to which the ordinary ship is unavoidably exposed, subjected to the least average of shocks and violent strains, and with its remarkable facilities for cleansing and ventilation, this propeller has everything to render it the most durable structure afloat.

Strength and Safety.

The form of the sustaining and supporting bodies, the material employed, the reserve of buoyancy, the assured stability and durability, the complete control within her own length, impossibility of immediate loss when stranded, and the small fire risks, all afford important integrant parts of strength and safety. Quoting the words of General E. W. Serrell, "The Fryer ship can be made strong enough to stand the shock of wave and wind at sea as well as any ship now afloat. I come to this conclusion after considering the quantity, direction and amount of all the forces that will operate."

The position of the engines will be such that they can never be flooded, nor can the ship be left to the mercy of the waves by the sea putting out the fires. Again, even if the wheels are broken and crushed from their bearings, the domes will but fall upon and hold them, while the vessel will become a life-raft at once, with its sails as a propelling power. Should she run aground, the spheroids can still be readily turned, while the hull will be far above any dangerous strain; and, in case of injury of any kind to the globes, the damaged part can be turned out of the water and repaired at sea almost as readily as in a dock.

Speed.

It is a curious sight to see a man navigating the sea in a revolving chair, but those who have seen the tricycles of Copenhagen may recall that they attain a high rate of speed, their stability and buoyancy at the same time making them comfortable and safe. Since the globe is the figure best calculated to overcome both fluid and air resistance, the spheroidal wheel and dome-shaped body present the most favorable form for securing great speed, while the momentum of the vast weight, when once started, has a tremendous force in overcoming resistance. In the Fryer there is no quick water from the wheels to

intensify the friction on the body. She is neither affected by the horizontal and vertical motions of the water as the after-body of the ordinary ship, by the drag of screw and rudder-post, nor by the violent water eddies as they rush through the propeller well. It may be argued that these pressures upon the after-body are favorable to speed; and so they are, but only when the particles are replaced gradually, which is the case in very few ships, and only under the most favorable circumstances. It may also be said that in this propeller there are three fore-bodies to one in the ordinary ship, without any favorable after pressure, but thel east resistance of the spheroidal form and the revolution of the sustaining bodies reduce this body resistance far below that of the generally accepted configuration.

There will be no wave raised in front of the fore-body by increasing speed, since the spheroids are constantly cleaving new water of uniform condition, and by their revolution raising themselves out of water instead of plunging deeper like the ordinary ship. Nor will there be the backward drag exerted by the particles of water on the usual immense skin. It is not uncommon to find the resistance increased about one-fourth by the roughness of a ship's bottom, which in a short time becomes covered with weeds and shells; sometimes it is more. It is needless to remark that this element of resistance will never enter the problem. Nor will we have to consider the action of our propelling power in any water that has already been disturbed by the vessel's action, since each spheroid acts independently upon the water in its separate path. The cleavage is as clean as a racing oar. The experiments with both models have shown no appreciable slip (though no slip is considered folly), while as to speed, the larger model showed an increase over the smaller.

Economy.

This question depends so greatly upon the cost of operating that it will be impossible to reach any important conclusions until further experiments are made. The results of those already effected certainly warrant the outlay of a further small amount to test particularly the cost of operation, slip and surface resistance, as well as to discover a relation between the resistance of the spheroids at rest and in revolution.

All estimates, however, show a large reduction on the first cost. Expenses will be still farther largely decreased, for the following reasons: There will be no decay of material by gases, dry rot or

confined dampness. The necessity of docking will no longer exist, as every part of the spheroids and body can be reached for inspection or repairs at sea or in port. There will be no deterioration of that large portion usually under water. With the increased stability there will be greater durability and fewer shocks and strains upon all rigging, fastenings and machinery. All of which will reduce the cost of operation, though the expenditure of coal remain proportional to the speed.

Sanitary Excellence.

The question of ventilation and sanitary method will be greatly simplified if not perfectly solved. The relative clearage not only abolishes all attention to the questions of those parts of a ship now below the water line, but provides an air space conducive of the greatest comfort and health. Convenient outlets in the bottom of the superstructure will eject all refuse, ash deposits and greasy matter, while the absence of bilge water will remove one of the most disastrous of health destroyers.

Uses.

Rapid development of application will speedily follow the successes of the first ship, but it may be interesting to recall some of the uses the invention will undoubtedly satisfy.

Naturally Mr. Fryer's ambition will not be fulfilled, no matter to what other objects his conception may be applied, until he has given the world an ocean steamship that will surpass in speed and comfort anything now afloat. But there are other uses which, if successful, will meet many of the world's requirements, and add great honor to the inventor's name.

For all scientific investigations of the sea, the peculiar qualities of the Fryer propeller are unusually well adapted, the small draft, stability and clearage offering unsurpassed facilities for sounding, surveying, dredging, trawling and other scientific work; facilities particularly appreciated by officers who have been engaged in deep-sea work, and who have seen many a day lost and the evidence of valuable work drift from their sight because of the absence of these very characteristics from the vessels under their command.

Experiments have so clearly shown little stern current, and no waves to right and left, that the question of canal and narrow river steam navigation will be solved; rapid steam transit through these water

ways being accomplished without destruction of the banks by the wave power and friction.

The buoyant, beaching and land-travelling qualities of the "Fryer" also admit of the development in the application to boats and rafts for life-saving and survey service.

Although the great extent of surface above the water line would render the buoyant propeller unfit for many war purposes, its facilities for transporting and landing men anywhere, and the peculiar adaptability for bomb, floating and coast batteries, would render it of vast importance for defense. Its stability afloat would permit the battery to be always available while in the water; readily run ashore and defended by a rapidly turned up earthwork, a shore battery would be most expeditiously constructed, while it can be as easily put afloat should necessity require advance or retreat.

The success of a Fryer ocean steamship to meet all the demands of passenger, mail and express service, will be quickly followed by others for the rapid carriage of fruits, stock and freight, and the Queen of England will not stop with the satisfaction that the "tricycles which have been used by her grandchildren have been beneficial to their health," but will request her ministers to add the "Fryer" tricycle propeller to the greatest of commercial marines.

NAVAL INSTITUTE, ANNAPOLIS, MD.

October 5, 1882.

P. Asst. Engineer W. A. Windsor, U. S. N., in the Chair.

THE PHYSALIA, OR PORTUGUESE MAN-OF-WAR.

By Midshipman W. E. Safford, U. S. N.

During a recent cruise in the West Indies I had the opportunity of closely observing the Portuguese Man-of-War, one of the most remarkable and most interesting of the ocean's inhabitants.

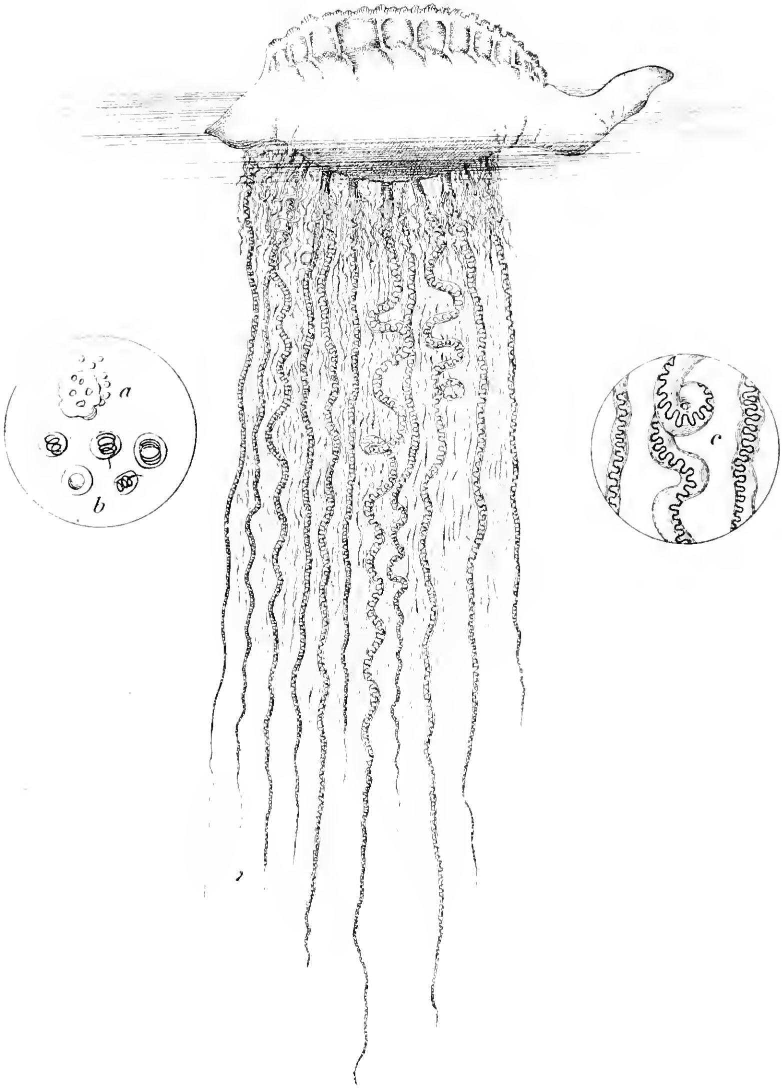
I had long felt a curiosity to examine for myself this little animal, regarding which I had read such varied and conflicting descriptions, and of whose nature nearly every naturalist seems to have formed a conception of his own. The *Physalia*, as the animal is known in scientific nomenclature, has, according to one author, the power of changing its color at will; another states that its colors are opaline or iridescent; and there are others, finally, who say that the colors are permanent or pigmental. In some figures the animal is represented with tentacles bearing discoid suckers like those of a *poulpe* or cuttle-fish, and by their side peculiar leaf-like appendages, the use of which does not seem to be clearly explained. It is also described as having, at the extremity of its vesicle or "bladder," a minute orifice for the admission and expulsion of air, with which the bladder is filled, and to which the animal owes its buoyancy. All descriptions which I have read unite in the statement that its stinging powers lie in the large mass of fleshy tentacles which extend from the keel of the little "man-of-war."

The Portuguese man-of-war consists of an elastic cylindrical air-bladder, from eight to twelve inches in length and three or four inches

in diameter. This tapers at each end to a point, one end being much more attenuated than the other, and apparently constituting the bow of the craft. This bow can be elongated or contracted at will, elevated, depressed, or moved laterally in any direction, like the proboscis of an elephant. Knowing that authors differed as to whether there was an orifice in the bow, I examined it carefully under a powerful magnifying glass, and found, not an orifice, but a dimple or umbilicus, around which the elastic tissue of the bladder is arranged in concentric rings. Comparing the animal to a ship, and using corresponding terms in its description, the bottom and bow are of a deep indigo color, blending into a lighter blue along the bilges, and to a faint lilac on the sides, above which it becomes almost perfectly transparent. Along its upper surface the bladder rises into a crest which has a slight resemblance to a lateen sail. This crest is simply a continuation of the bladder, forming with it a single air-chamber. Its cross-section is A-shaped, and is divided into eleven folds or segments by transverse membranes, as shown in the figure. The tip of the crest is edged with a beautiful frill of a delicate rose color, which is highly contractile, and by means of which the sail is taken in and folded over to the left.

From a fore-and-aft line, corresponding to the keel of a vessel, extend a mass of fleshy tentacles varying in length from a few inches to fifteen feet. These tentacles are of three classes, performing the offices respectively of nutrition, reproduction, and propulsion. They are united in sets to the bladder by means of short translucent tubes, each tube bearing tentacles of the three classes. They do not bear anything resembling suckers, but have each, in a longitudinal line, a purple fold or frill as shown in *c*. Specimens of this frill when examined under the microscope showed that it consisted of large pigmented cells, covered with smaller cells as shown at *a*. Under 600 diameters these smaller cells proved to be *nematocysts* or thread-cells, as shown at *b*. These consist of a simple cell in which there is a coiled spiral thread which is highly elastic. Under the slightest pressure the spiral straightens itself out, extending through the cell-wall, and penetrating its victim with the sharp barbed point, which remains in the wound.

Knowing the animal's stinging powers, I was very careful not to allow my hand to come in contact with its tentacles; but what was my unpleasant surprise when on touching the lower surface of its bow, in examining the alleged orifice, to feel a burning sensation so



J FRIEDENWALD, LITH BALTO

intense that it seemed as though my hand had touched a red-hot coal. This was communicated to my cheek, which I accidentally touched with my hand, and the pain continued for more than twelve hours. On examination I found that the whole lower surface of the body contained multitudes of thread-cells, of a smaller size, however, than those of the tentacles. When I would seize it by the crest, the little animal would turn over on its side and raise its proboscis to my hand as though attempting to sting it.

It was impossible for me to conceive the Physalia to be a colony of individuals, as is held by eminent naturalists. It would swim around the margin of its prison, carefully touching every point with its proboscis, at times raising it several inches above the surface, as though seeking to escape. Then it would fall back and writhe as if in despair. It is true that it does possess many sets of mouths, propellers, and organs of reproduction; yet we must remember that its organization is even lower than that of a mollusc; and may it not be nourished as a plant is nourished? A creeping plant is an individual, and yet it receives its nourishment from a hundred sets of rootlets, and it may bear any number of flowers possessing perfect ovaries. And just as the plant may be propagated by cuttings, so may the Physalia reproduce by gemmation or budding.

The bladder of the Physalia is double-walled; that is, it consists of two membranes, one fitting tightly within the other as a rubber football fits within its cover; but the use of the second membrane does not seem to have been understood by any of the writers whose descriptions I have read. With a sharp needle I pierced the bladder, thrusting it fully an inch through the two membranes. On withdrawing it, the wonderful part which the second membrane played in the economy of the animal was revealed. The orifice was closed almost instantly by the sliding of the outer membrane upon the inner, through the space of about the tenth of an inch, thus interrupting the coincidence of the punctures in the outer and the inner membranes.

Again and again I pierced the bladder, but every time the puncture was closed as promptly as before; and not even by thrusting the animal below the surface with a forked stick could I cause it to part with a bubble of air. Were it not for this happy faculty of closing small punctures in its bladder, the slightest wound from the spine of a fish or an echinoderm would be sufficient to make it collapse and sink to the bottom.

In conclusion I would say that naval officers often have excellent

opportunities for observing animals whose habits are as yet unknown to the naturalist; such, for instance, as many pteropod molluscs, the beautiful Argonaut, and the little glassy Vellela. And not only may they be the means of contributing to the natural history of the globe; but to those whose life is spent upon the surface of the ocean, the study of the wonderful and varied forms of the life within its depths cannot but prove intensely interesting.

DISCUSSION.

P. Asst. Surgeon D. N. Bertolette.—While the double wall of the air-bladder or pneumatocyst may aid in preventing the escape of air from accidental punctures, it is not absolutely necessary that the membrane should be doubled to obtain the same result. When a fibrous membrane is pierced by a smooth slender instrument such as an ordinary sewing needle, the fibres are not ruptured or torn, but merely separated until the withdrawal of the foreign body, when their elasticity brings them back to their former position, and what was a theoretical opening is now practically closed. This observation refers only to punctures of very small diameter. The circular fibres surrounding the dimple where Mr. Safford looked for the opening connecting the air-vesicle with the air, were possibly a sort of sphincter muscle controlling this opening. These muscles closing the opening with a spasm probably accounts for the lecturer's want of success in discovering it. Nearly all the congeners of the Physalia have these openings, or stigmata, communications between the cyst and the open air, and it is most probable that the Portuguese Man-of-War is similarly supplied.

The Cnidæ, nematocysts or thread-cells are peculiar structures common to the Cœlenterata. They consist of small oval cells tensely filled with fluid, and containing a spirally coiled filament barbed at its base and finely serrated along the sides. Upon the slightest pressure these cells rupture and the filament is suddenly uncoiled, projecting a considerable distance. While even in the more minute Hydra these cells have some benumbing and deleterious influence upon animal organisms captured as prey, still comparatively few have the power of puncturing the human skin. Mr. Safford's observation that he had produced pain in his cheek by touching it with a finger which had been stung by a Physalia is possibly new, and is certainly worth further investigation.

Midshipman W. E. Safford.—In reply to Dr. Bertolette, I would say that the needle which I used in piercing the vesicle was so coarse as to cause an orifice perceptible to the naked eye, and the punctures of the inner and the outer membranes were distinctly visible after their coincidence had been interrupted, the inner one showing through the outer membrane about the tenth of an inch from the outer puncture.

All observers seem to unite in remarking that there are no muscles whatever in the vesicle of the Physalia, and it was only after carefully examining a thin section of the membrane around the "umbilicus," that I concluded there was no orifice at that point. Professor Huxley in his "Anatomy of Invertebrates" does not mention such an opening, nor does Professor Agassiz, in his "Contributions to the Natural History of the United States," in which he gives an excellent description of the animal.

Regarding the animal's stinging powers, M. Gervais says of a sufferer: "*Qu'un vase qui avait renfermé une physalie vivante n'ayant pas été suffisamment nettoyé, il se brûla les lèvres, le nez et les joues en se servant de ce vase pour se laver.*"

NAVAL INSTITUTE, ANNAPOLIS, MD.

DECEMBER, 1882.

THE WAR WITH MEXICO: THE CRUISE OF THE U. S. SHIP CYANE DURING THE YEARS 1845–48.

From the Papers of her Commander, the late Rear-Admiral S. F. Dupont.

The Cyane was commissioned in July, and sailed from Norfolk on the 10th of August, 1845, under Captain Wm. Mervine, destined for the Pacific station. After calling at Rio Janeiro, Valparaiso, and Callao, she reached Mazatlan, on the west coast of Mexico, in January, 1846, where she found the American squadron, under Commodore Sloat, watching the course of events in that republic.

A few weeks after, a special messenger arrived from the United States, who was conveyed in the Cyane, first to the Sandwich Islands, and thence to Monterey, in Upper California; the ship immediately rejoining the Commodore at Mazatlan on the 30th of April, where she found, in addition, the English Rear-Admiral with his line-of-battle-ship and two other vessels of his fleet, having, it was supposed, an eye to the movements of the American Commodore.

The Cyane sailed for Monterey again in May, arriving there on the 20th June. On the 2d July the flagship Savannah arrived. With these two ships, and the Levant, Captain Page, Commodore Sloat took possession of Monterey and proclaimed American authority in the Territory of California. As Captain Mervine commanded the landing party, his ship had the honor of furnishing and hoisting the first American flag. Two days later, the 9th June, the Portsmouth, Captain Montgomery, took possession of the bay of San Francisco, hoisting the flag at its principal town, Yerba Buena. Through his arrangements it was flying a few days after at Sutter's Fort, on the Sacramento, at Sonoma, and Bodega, all of which was announced on the 14th of July, in a general order by Commodore Sloat.

On the 14th July, the frigate Congress, Commodore Stockton, arrived at Monterey. She was a timely accession to the squadron, for foreign interference was still anticipated by some, and, as if in confirmation of it, on the following day, the Collingwood, 80, Rear-Admiral Sir George Seymour, anchored in the harbor, while the Juno frigate was at San Francisco. Whatever might have been the original intention, the game was blocked.

Commodore Sloat having relinquished the command of the squadron to Commodore Stockton, the command of the Savannah frigate became vacant and was assigned to Captain Mervine, who was succeeded in the Cyane by Commander Du Pont, on the 23d July, 1846. The ship was despatched immediately to San Diego, having first received on board Major Frémont's battalion, which had reached Monterey about ten days after its occupation by the squadron.

The Cyane ran down to San Diego in three days, where she made a prize of the Mexican brig Juanita, just preparing to leave the harbor, on board of which forty thousand percussion caps were found,—an opportune and acceptable seizure. A party of sailors and marines under Lieutenant Rowan were immediately landed, who marched up to the town, took possession, hoisted the flag and left the marine guard to garrison it. In the evening Major Frémont landed with a portion of his detachment, and the remainder followed the next day. Their object was to procure horses, and to operate in conjunction with Commodore Stockton upon Los Angeles, the capital. All communication was cut off by land, and the launch was sent to San Pedro to report to Commodore Stockton the capture of San Diego. The launch returned with orders for the Cyane to join him at San Pedro. On her way up, the ship made a prize of the Mexican brig Primavera from San Blas. In the meantime the Commodore had marched on Los Angeles, and General Castro, falling back, had made good his retreat, the California battalion not having been able to procure horses in time to intercept him, as originally planned.

The conquest of California having been thus effected by the squadron, successively under Commodores Sloat and Stockton, the Cyane was despatched to blockade on the west coast of Mexico, and to cruise in the Gulf of California. She sailed from San Pedro on the 24th of August with a limited supply of provisions, leaving behind her marine guard to assist in holding the territory. The ship arrived at San Blas on the 2d day of September, and captured two Mexican vessels entering the harbor with valuable cargoes for the

interior of Mexico. A reconnoitering party was sent on shore, which spiked all the guns that could be seen, good, bad and indifferent, thirty-four in number, and the ship sailed for Mazatlan. Off this port she met the Warren, Captain Hull, blockading and endeavoring to procure funds for the squadron: her boats, under Lieutenants Radford and Renshaw and Acting Master Montgomery, had just cut out the brig Malek Adhel in handsome style. The Cyane passed on to the bay of La Paz, Lower California, and anchored at dark in the harbor of Pichilinque. Her boats were despatched to the harbor and town of La Paz, six miles higher, where seven Mexican vessels, brigs, schooners and small craft, laid up for the hurricane season, were made prizes. One of these, a fine Baltimore-built schooner, the Julia, was fitted out, officered and manned, and despatched to Upper California, where, throughout the subsequent difficulties, for more than a year, she rendered important service as one of the squadron.

Arrangements were made with Don Mirando Palacios, the Governor of Lower California, for the neutrality of the province. Water was procured and such supplies as the place afforded. The Warren came in for water on her way to Upper California, and was supplied from the Cyane with some cordage and canvas which she much required. The Cyane then sailed on the 28th September to scour the Gulf. Coasting along, she visited the port of Loreto, the bay of Mulejé, never before visited by an American vessel, took two or three small craft, and crossed over to Guaymas, entering the inner harbor. The enemy here burnt two gunboats which the ship had been seeking. A Mexican brig, securely moored with chains within pistol range of the town, was cut out by the boats of the ship, under a sharp fire from artillery and musketry, a large force being stationed in the town. This affair, the particulars of which reached the United States through a published private letter, seemed to be appreciated.

From Guaymas, the Cyane proceeded to Mazatlan, which place she reached in fifty hours, having had a brig in tow half the distance. At Mazatlan, the blockade was established and strictly enforced. Attempts were made to supply the town with flour by means of small vessels, which by taking advantage of the strong sea breeze, and passing inside of the islands and close to the beach and breakers, would make for the old harbor which the ship could not cover. The boats, necessarily the smallest, had to cut off this traffic, but while so engaged were always exposed to the fire of the enemy, who brought field artillery and musketry to bear upon them from the surrounding

heights. Three vessels were driven into the breakers under these circumstances and their cargoes destroyed. While returning from one of these excursions, some large launches, filled with strong guards of soldiers, put out from the old harbor to intercept the boats. These, though the three smallest, under Lieutenants Harrison and Higgins and Acting Master Stenson, formed a line, bore down upon the launches, and opening upon them with musketry, soon drove them back into the breakers and high and dry on the beach. In all these affairs the men and officers showed great gallantry, to which the latter superadded skill and management.

A storeship was anxiously looked for, but none came; provisions were at a low ebb, and the blockade had to be relinquished. After looking into San Blas a second time, returning off Mazatlan, and crossing over to fill up with water at San José, Lower California, where a man-of-war anchored for the first time, the Cyane had to make the best of her way to San Francisco, where she arrived the 1st of December after the shortest passage ever made (seventeen days), her crew on short rations, and at the bleakest season, without stores, but also without a murmur.

Stirring intelligence awaited the Cyane at San Francisco. Since her departure from the coast, in August, a strong reaction in the feelings of the country, and a formidable resistance to American authority in Upper California had sprung up, for reasons unnecessary to mention. Important positions where garrisons from the squadron had not been left, or where ships could not protect such as were left, had been retaken by the enemy. At San Diego the volunteer force had been driven out; but reinforced by the captain and crew of an American whale-ship, had gallantly regained its post. Captain Talbot with a guard of ten or twelve men at Santa Barbara, had been summoned to surrender, but refusing, had marched out with his arms and made good his retreat the whole distance to Monterey, after a most harassing march, having displayed heroic gallantry and endurance. At Los Angeles, the capital, another detachment of the California battalion, surrounded by a large force, with their supplies cut off, had been obliged to embark at San Pedro after an honorable capitulation. The two frigates had immediately gone down on hearing of the loss of the capital, with the intention of retaking it and reestablishing the garrison, but San Pedro was found an unsuitable point to operate from, and the Congress stood for San Diego, while the Savannah was sent north to hold the upper country, for even there, the most friendly portion, the enemy were organizing.

The Savannah, with the Warren, was thus holding the bay of San Francisco. Besides Yerba Buena, the headquarters of the district, they had a force in a small schooner in the straits of Carquinez, under Lieutenant Carter, garrisons at Sonoma on the northern, and at the Pueblo of San José on the southern shore of the bay, respectively under Lieutenants Maury and Pinkney. The Savannah had, moreover, a party of sailors at San Diego and another at Monterey, where the Congress had also left a detachment, and the Cyane's marines were there. Indeed the officers and crews of the squadron were scattered over the whole coast. Every ship, too, was short of her complement, but these naval garrisons, popular with the people of the country, who had besides a high estimate of their prowess, held matters in check much more than their numerical strength would seem to justify. About this time, the arrival of the Dale, Captain McKean, was a welcome accession. Leaving her marines at Yerba Buena, she sailed in a few days for Monterey, the garrison there being without the protection of a vessel of war.

The enemy were active. They were driving off the animals; and had captured a lieutenant and six men but a few miles from Yerba Buena, who were foraging after cattle. Inland communication was cut off, provisions were short, storeships did not arrive, but every man was up and doing.

It may as well be stated in this connection that the movement of the enemy in the upper district was put down so soon as he had concentrated his forces. This he did at the mission of Santa Clara, sixty miles from Yerba Buena, under Sanchez. An expedition, first suggested by Lieutenant Pinkney, commanding at San José, whose position gave him an opportunity of watching the enemy's motions, was organized. It consisted of a party of sailors from the ships, with a piece of artillery under Acting Master De Jongh, some marines from the garrison of Yerba Buena under Lieutenant Tansill, and a party of its spirited citizens under Mr. Smith, all under Captain Marston of the marines. Another force was to march from San José under Captain Webber, while Lieutenant Maddox, raising a mounted party of some seamen of the Congress, three or four marines, enlisted volunteers, and deserters from whale-ships, sixty-five in all, came the whole distance from Monterey, over one hundred miles. It was in the height of the rainy season, the country was flooded around Santa Clara, the bogs and gulches almost impassable, while the streams, which the party from Monterey had to ford, were all swollen, and the

roads were in a dreadful condition. The parties, however, came in nearly at the same time, just as the enemy had made a dash at the Yerba Buena force, seizing the moment when their piece of artillery seemed irrecoverably bogged. They were driven back, asked for terms, laid down their arms, and liberated the lieutenant and six men above alluded to. Thus was the upper district quieted.

Lieutenant-Colonel Frémont had broken up his camp at San Juan, some five leagues from Monterey, and commenced his march south. The Cyane's prize, the Julia, Lieutenant Selden, had been placed at his disposition by Captain Mervine, and she had proceeded to Monterey and taken on board a piece of artillery and other articles, which she delivered to the battalion at Santa Barbara. She then followed the coast, to give protection to the marching force, where the road, passing close to the water's edge, was commanded by the impending heights, but which, in turn, could be swept by the schooner's gun. This was specially the case at the remarkable pass of the Rincon, where the column had greatly to extend itself, and the whole force could have been raked, and seriously impeded by a few resolute men. The schooner in performing this service was frequently close to the breakers, and in imminent peril.

The commander-in-chief, Commodore Stockton, was at San Diego. He had succeeded in getting his large frigate into its small and shallow harbor, and was preparing with energy to retake the capital, but under very adverse circumstances—as he was short of provisions, of clothing, and without funds. Animals too were very scarce, and the few obtained were only procured at great risk to the parties sent out. Orders were found at San Francisco for the Cyane to join him immediately. Filling up with water and getting what scanty supplies the place afforded, she proceeded to San Diego (whither the Portsmouth had preceded her), arriving just in time to furnish one hundred and eight men and officers to the expedition under Commodore Stockton and General Kearney, who thus were present at the battles of San Gabriel and the Mesa, fought on the 8th and 9th January, 1847, the particulars of which are too well known to need recapitulation here. This detachment of the crew and officers returned by sea from San Pedro, exulting in their good fortune, that after an eventful cruise on the west coast of Mexico, and in the Gulf of California, they should have got back in time to share with their comrades of the squadron, in the second and final subjugation of Upper California, as they had previously done in the first. They brought

back with them from Los Angeles, as a trophy, a very small brass cannon (three-pounder), which being mounted on board as a field piece, was ever afterwards a highly prized and constant companion in their different expeditions.

From San Diego the Cyane was ordered to Monterey, having received on board General Kearney and staff, and Lieutenant Warner, with the topographical party which had accompanied the General in his great and laborious march through New Mexico to the shores of the Pacific. Mr. Larkin, American Consul in California before the occupation, and lately a prisoner of war, also came on board. At Monterey she fell in, unexpectedly, with the Independence, Commodore Shubrick, who had assumed command of the squadron, and the Lexington, Lieutenant-Commanding Bailey; the latter having brought out a large supply of ordnance and ordnance stores, and a fine company of the 3d Artillery, whose encampment on the heights above the town was an interesting sight, as the first harbinger of relief to sailor garrisons, and promising service for the squadron on some new theatre.

The Cyane continued on to San Francisco, with General Kearney and the engineer officers, having got back at Monterey her marine guard, that had been six months out of the ship. On entering the harbor of San Francisco she fell in with the Erie, Lieutenant-Commanding Turner, having Colonel Mason on board, just from Panama.

The Savannah and Warren were ordered to Monterey, the former to prepare for her return home, taking the crews of both, whose terms of service had long expired. The Cyane was thus left in charge of the northern district, and had soon to send her marines and some sailors to Sonoma to protect the inhabitants against Indian depredations.

On the 2d March, 1847, the Columbus, Commodore Biddle, arrived at Monterey, and the latter assumed the command of the squadron. On the 7th March, the first instalment of the New York regiment, Colonel Stevenson, came in, soon followed by the others, and on the 16th the first of the long looked-for storeships.

On the 9th April the Cyane was ordered to Monterey, and despatched by Commodore Biddle to blockade Mazatlan, which she did until late in June; when she was directed to visit the Sandwich Islands, with an eye to the great whaling fleet, and see if any privateers, likely to molest it, had been heard of, three vessels with Mexican papers having cleared at London, under very suspicious circum-

stances, for Manilla, the names and description of which had been obtained. The Cyane visited Hilo, in Hawaii, and Honolulu. Her visit seemed appreciated by our hardy and enterprising whalemen; they were informed of the progress of the war, and of there being no danger for their returning ships. The presence of the Cyane was opportune in other respects, and seemed to give general satisfaction.

The ship sailed for Monterey on the 6th September, and reached it on the 26th, where she found the Independence, Commodore Shubrick, who was again in command of the squadron, and preparing with great zeal for active operations on the west coast of Mexico, as the quiet state of Upper California, under the able administration of Colonel Mason, the Governor, rendered his presence in that quarter no longer necessary. He had already despatched the Congress, Captain Lavallette, and Portsmouth, to cruise in the Gulf of California, to be ready to meet him off Cape San Lucas, the moment the season for operations opened.

The squadron had cause to be thankful to Colonel Mason for the liberal interest he took in furthering, in every way in his power, the views of the commander-in-chief, supplying ordnance for fortifications, mortars, shell, &c., and, what proved of the utmost value, the sailor companies were furnished with fine army muskets and accoutrements, in lieu of their old worn-out navy ones and the still more worthless carbines. He, moreover, gave the squadron the valuable services of Lieutenant Halleck of the Engineers, who embarked on board the flagship.

On the 17th October, 1847, the Independence, Cyane, and Erie, Lieutenant-Commanding Watson, sailed from Monterey. The Southampton, Lieutenant-Commanding Thorburn, had been despatched to San Francisco to bring down ordnance, implements for fortifying, &c. On the 30th October the Congress was fallen in with; she had, with the Portsmouth, bombarded Guaymas, and left the latter to hold it. On communicating with Cape San Lucas, information was received of apprehended disturbances in Lower California, and the ships stood into San José and anchored. A mounted party of sailors and marines from the Independence was sent over to Todos Santos, on the west coast of the peninsula, where an armed force was said to be organizing. The party returned after a hard ride of five days, had met no body of men, and heard nothing very definite as to a contemplated resistance.

For the better understanding of affairs in Lower California, it may be well to mention that the Portsmouth, as early as March, had been directed to take possession of it, that is, the flag had been hoisted at San José and La Paz, and alcaldes and collectors appointed, but no garrisons were left, there being none to leave. In July, however, the Lexington, Lieutenant-Commanding Bailey, brought down Lieutenant-Colonel Burton, with two companies (not full) of the New York regiment, one hundred and six all told, who garrisoned La Paz, the Lexington remaining in the harbor until relieved by the Dale, Captain Selfridge. After events gave cause to regret these measures, particularly as Lower California was not retained by the treaty. It had remained neutral, unarmed, and the squadron got its supplies freely, but when incited to resistance by the State governments of Sonora and Sinaloa, who granted commissions to Mexican officers to raise forces, sending over arms and bands of Indians, the protection necessary to be given to our small garrisons, and which could not always be afforded, greatly embarrassed and limited the operations of the squadron on the west coast.

At the earnest solicitations of the alcalde and collector of San José to give countenance to their authority (for an outbreak had not then occurred), the commander-in-chief left another small garrison, consisting of four officers and twenty marines, ten of them, with the lamented Passed Midshipman McLanahan, furnished from the Cyane, all under Lieutenant Heywood, of the Independence. With the work expected on the other coast, even this small force was left with regret; for the two frigates were each over sixty short of their number, and not a marine guard reached even the meagre complement now allowed. This deficiency of marines would have been still more sorely felt throughout all the operations in the Pacific, but for the admirable zeal with which the sea-officers made themselves acquainted with the company, and, to some extent, the battalion drill, a zeal which was fully responded to by the seamen themselves, who all became respectable infantry.

On the 8th November, Commodore Shubrick, with the Independence, Congress, and Cyane, sailed for Mazatlan from San José. Mazatlan is a place of more importance than has been generally supposed. It is a well-built town, contains eleven thousand inhabitants, has some princely mercantile establishments, consular residences, a large foreign commerce and internal trade, and has been known to yield three millions of dollars revenue in one year to the Mexican custom-house.

Indeed, from Cape Horn to the Columbia river it stands only second to Valparaiso in commercial importance. Of course this is the result of foreign capital and foreign enterprise (not Mexican), and that within a few years. There were cannon in the place, although it was not fortified, but its contiguous islands, projecting points and commanding eminences rendered it susceptible of quick and easy defense against ships, while its surf-guarded shore was almost certain to limit its attack by boats from the harbor; but even here there were shoals to avoid, and a bar, often rough, to pass, while the channel was overlooked all the way by an elevated ridge, from which a few pieces of artillery could have hurled great destruction. Mazatlan was generally garrisoned by from nine hundred to twelve hundred men; it was within easy reach of reinforcements from states that had not contributed a single quota to the war. It was known, too, that the squadron contemplated taking it.

On the 10th of November, in the afternoon, the ships came in sight of it. The position of each had been assigned and marked on a plan of the coast and harbor, furnished the commanders. The wind, however, was moderating, and the commander-in-chief inquired if the ships could take their positions after dark, and being answered in the affirmative, directed them to proceed. The Congress led off in fine style to that bend in the coast outside known as the "old harbor," where, the shore being low, she could command some of the avenues leading from the town, and effectually cover the landing should the surf permit that point to be selected. It was a hazardous anchorage, but an important position, and boldly taken. The flagship stood for another slight bend in the peninsula on which Mazatlan is situated, and where a break in the coast range exposes to view from the westward the most important part of the town, which she brought to bear immediately under her guns. The Cyane kept on to get her station in the new harbor, her light draught enabling her to get sufficiently close to the bar for her 8-inch guns to reach the wharf and cover the landing, should that point be selected. She placed herself in four fathoms of water, where, with a stiff sea breeze, it often broke. Just before doubling Creston she could see that the frigates had secured their berths. The Independence in her majestic length just swinging around, showing her gun-deck tier of lights, and her stern almost in the rollers, presented a most imposing spectacle, causing astonishment and dismay in the town, a ship never having anchored there before. The Erie, which had separated from the squadron in a fog, and had

not stopped at San José, was found in her station off Creston to repeat signals. H. B. M. brig Spy was the only vessel in the harbor. The manner in which the ships took up their positions and invested the town elicited encomiums from some not given to complimenting the country of the Stars and Stripes.

Early on the morning of 11th November, Mazatlan was summoned to surrender, Captain Lavallette bearing the message from Commodore Shubrick. What passed is not precisely remembered, but the military commandant made no reply, and is said to have torn up the summons. The civil authority was ready to deliver up the town; the garrison was still there, and their course was doubtful. Immediate orders were given to prepare to land, and the hour of twelve fixed upon. The surf outside was too high, and the usual landing place was designated. The boats from the Independence, Congress, and Erie on entering the harbor were joined by those of the Cyane, and this ship had her broadside sprung to cover the disembarking, if necessary.

There were three lines of boats. A division of the Congress, under Lieutenant Livingston, had five pieces of artillery, captured in Upper California, and mounted on board that ship; those of the Independence were under Lieutenant Page, all under the immediate direction of Captain Lavallette, the commander-in-chief being in advance of all. Passing one or two points, from which most serious opposition might have been made, without seeing a foe, it became probable none would be attempted, yet the heights near the landing, the streets and the houses with terraces, warned that no precaution should be neglected. The men were on shore in a twinkling, and the companies formed while the artillery was landing; a work of labor, but successfully accomplished. The whole force, about seven hundred and fifty strong, Captain Zeilin, adjutant, marched through the town to the Cuartel, situated on a mound in its rear overlooking the surrounding country, on the walls of which the flag had been hoisted, the Independence saluting with twenty-one guns. There were no laurels reaped, but the capture was not the less important, and it brought home to the impracticable Mexican that his commercial emporium in the west had shared the fate of the one in the east, while the American flag waved over the national palace in his capital, the squadron having just heard of the entrance into it of our glorious army.

Measures were immediately taken for the defence and holding of Mazatlan, and for its municipal government. Captain Lavallette was

made governor, and a garrison of four hundred seamen and marines established. A commission, of which Lieutenant Chatard, Purser R. M. Price and Mr. Thos. Miller were members, arranged with the municipal Junta the terms of occupation. The frigates moved into the harbor. The custom-house was opened and organized, and under the control and business experience of Mr. H. W. Greene, Purser of the Independence, assisted by Mr. Speiden of the Congress, upwards of two hundred thousand dollars, duties, were collected in five months. The commander-in-chief having given an order that the discharging of vessels at points on the coast which had been declared ports of entry since the war, in order to avoid blockades, was contrary to the law of nations, the commerce was fast coming to Mazatlan. Moreover the Lexington, Lieutenant-Commanding Bailey, on her arrival from Upper California, was despatched to blockade the Port of San Blas, and the American barque Whitton, chartered and manned, under Lieutenant Chatard, that of Manzanilla. On her way down, the Whitton called in at San Blas with the Lexington. An expedition from both ships landed and brought off, from the upper town, a couple of cannon, which completed the armament of the Whitton. At Manzanilla, Lieutenant Chatard landed with fifteen men and spiked five guns; the enemy, two hundred strong, were close in the vicinity.

The Mexican forces, however, had retired but a short distance from Mazatlan, and were intercepting all supplies coming into the town. An expedition of boats with two companies from the Cyane and Independence, under Lieutenant Rowan, pulling up at night through the esteros, some four miles, landed at Ureas, and surprised and drove in an outpost, while another force of seamen from the Independence, Congress, and Cyane (a part of the garrison), under Lieutenant Selden, left the Cuartel at midnight, had a bush-fight three miles out, and, forming a junction with the force from the estero, stormed the headquarters of the ex-captain of the port, a piratical German, who, with a detachment of soldiers and a strong band of matriculados (enrolled sailors), was obstructing the roads, cutting off provisions, and robbing the mails. They were routed in all directions, and this blow unexpectedly struck, followed up by bold scouting at night in smaller parties under Lieutenants Lewis, Stanley, McRae, and others, effectually cleared the avenues for the admission of supplies.

This expedition, however, suffered some loss, one man of the Independence was killed, with twenty wounded from the different ships, some very severely.

Mazatlan being liable to a *coup de main* at any time from a large force, the labor on the fortifications was pressed forward under the direction of Lieutenant Halleck (Engineers). This gentleman was also filling the functions of lieutenant-governor, and his services were always freely tendered to the sea officers in their expeditions and scouting parties, in the most important of which he participated. But the breaking of new earth, the strong miasma from the esteros and marismas, the hot sun by day and the scouting by night, soon brought fever among the crews. Those at the outer post in particular, where the works, under the untiring energy of Lieutenant Tilghman, had been prosecuted with the utmost vigor, suffered most. The frigates had over sixty cases each at one time, and the Cyane thirty; the Congress' gun-deck seemed a hospital.

At this very time news reached Mazatlan of an outbreak in Lower California. Lietenant Heywood, at San José, had repulsed a well planned attack upon him, and the leader of the Mexicans, a Spaniard by birth, being killed, the enemy was driven back, although he outnumbered the garrison six to one. The Portsmouth was sent over to strengthen that post.

At La Paz, Lieutenant-Colonel Burton had resisted one attempt to dislodge him, but at the last accounts was surrounded and fighting. The Cyane was immediately despatched to his support. Getting on board her men and officers from the Cuartel, her quota of the garrison, but leaving her marines, and with thirty on the sick list, she left Mazatlan on the 2d December, and arrived at La Paz on the 7th. The ship passed up the channel and anchored close to the town; for among her many admirable qualities, though carrying heavy guns, she had a light draught of water. Lieutenant-Colonel Burton with his command, consisting, as already stated, of two incomplete companies of the New York regiment, had most gallantly repelled two assaults of the enemy and had dislodged a party that had got into some old works, capturing their flag. Affairs were in a sad condition: the country was in a state of complete resistance, the Mexican forces keeping in awe that portion of the inhabitants who were friendly. Mounted parties of the enemy were still hovering around, the town was abandoned by the inhabitants, many women and children had taken refuge on board the old hulks and small craft anchored in the harbor, the houses of the well-disposed had been sacked, and two handsome residences, one in, and the other near the town, the property of the ex-governor, had been burnt and devastated. Lieutenant-Colonel

Burton had availed himself to the fullest extent of the means at hand (most inadequate) to entrench and fortify himself, and his military education came into good play.

A day or two after the arrival of the ship, an expedition in the launch and cutter was sent up as far as the shallow waters would admit, to support a company from the post sent out after cattle, and who seemed engaged with the enemy near the Palo, three miles up, but the latter retreated, escaping an ambush laid for him. The launch on another occasion, with her gun, had been sent some fifteen miles up the bay, there to intercept another party, said to be driving down horses. Confidence was thus restored, the enemy gradually disappeared, and the people, trusting in the additional protection to be expected from the ship, as she furnished a detachment to the post whenever an attack was expected, returned to their homes.

Towards the latter part of December, the Dale arrived and remained a few days. This little ship rendered good service in the Gulf, and while holding Guaymas, successively under Commander Selfridge, Lieutenant Yard and Commander Rudd, some most spirited and daring enterprises, even to the surprising of the enemy's camp, were performed by Lieutenants Craven, Smith, Stanley and Tansill, both by boats and landing parties.

Intelligence began to reach La Paz that the enemy was daily increasing in numbers in the valley of San José, it affording good support for his animals. The inland communication was cut off, and the reports contradictory. Finally it was ascertained that two officers and three men belonging to the post of San José, while attempting to go to the bay side, had been intercepted and made prisoners, and it was reported that the post itself was short of provisions. To ascertain the actual state of things, Acting Lieutenant McRea went down the coast in a small leaky *balandra*, landed at night, communicated with Lieutenant Heywood, and succeeded in getting on board the sloop again. This was a bold and hazardous enterprise (for the Indians gave no quarter), executed with spirit and intelligence; and this officer, continuing on to Mazatlan, carried the necessary information to the commander-in-chief, who immediately despatched the Southampton to La Paz, that the Cyane might go to the relief of San José.

It appeared that the enemy, abandoning all hope of effecting anything against La Paz, was concentrating all his forces, estimated from three to five hundred men, with the exception of a detachment at his headquarters at San Antonio, sixty miles from La Paz, around San

José, garrisoned by less than forty-five effective men under Lieutenant Heywood, who had successfully and heroically repulsed their repeated attacks; but his provisions were nearly exhausted and his water cut off, while the enemy was drawing hourly more closely the mesh intended to envelop him. The town was abandoned by the inhabitants, most of them driven off by the enemy, others doubtful of the result, fearing to compromise themselves. The Mexican forces occupied the large church and other strong buildings, looped and barricaded, and were arrogant and boastful, scouting the idea of a sloop-of-war bringing relief, saying that one of the frigates would have to come from Mazatlan, and calling upon the post to surrender.

The Cyane was anchored on the 14th of February, in the evening. Appearances were in keeping with the worst intelligence. The American flag was flying, it was true, but more than one on board believed it might be a ruse, and that the post had fallen. There was a calm determination to retake it at whatever cost, but daylight was waited for, sailors being unsuited to night attacks on shore.

The valley between the beach and Cuartel was occupied by the enemy from three to four hundred strong, placed in ambush, and with full knowledge of the ground. One hundred officers, seamen and marines (only five of the latter), with the small field-piece, under Acting Master Fairfax, were landed and encountered a spirited resistance all the way up from the different covers; but the enemy was always driven back, and well punished. At one time he concentrated his forces in the village of San Vincente, situated on a mound, through which the column had to pass, giving him a very advantageous position, but a steady advance drove him out here, too, and in good style. The garrison seeing the approach of the Cyane's men under a hot fire, formed, and, driving a detachment of Mexicans out of the town, came out to meet them, and a joyous meeting it was. Of all the services performed by the officers and men during the cruise, this was the most gratifying. They had brought relief to a band of brave men who had done wonders to relieve themselves. But no resolution can long contend with thirst and hunger, and these were close at hand.

The garrison was provisioned and strengthened, the valley immediately around San José was cleared, communication was re-established with the ship, and scouting parties were organized. One of these, twenty-five strong, was surrounded by a large body, but Lieutenant McRea, who was in charge, with a midshipman and a corporal

of marines, were so cool in their energy, and the sailors withal so steady, that they extricated themselves without loss, killing five of the enemy; a party from the Cuartel, under Passed Midshipman Stevens, had gone out quickly to their support, when the enemy retreated. An attempt was made to surprise the enemy's camp at Santa Annita, eleven miles out, by a night march, with a hundred men from the ship and garrison, who encircled it at early dawn, but the enemy getting word through an Indian spy, had suddenly decamped, leaving his fires burning. His forge and armorer were taken. Animals were then brought in, mounted parties of sailors and marines, with a few bold and friendly Californians, were equipped, and in a few days there was not an enemy left from Cape San Lucas to Santiago, a distance of nearly seventy miles. The former inhabitants of San Jose returned to their homes, the gardeners went to their huertas, the corn was planted, the cane was cut, the smoke from the sugar-mills once more curled over the beautiful valley, and this change from desolation to a smiling and happy population was gratifying to all who witnessed it.

It should be mentioned that Lieutenant-Colonel Burton having gathered in some horses, a mounted party of thirty men under Captain Steele and Lieutenant Scott, accompanied by Lieutenant Halleck (Engineers) and Dr. Perry, surgeon of the regiment, had surprised San Antonio, having a garrison quite equal in number to the party. They liberated five American prisoners, took two Mexican officers, and came near capturing the commander-in-chief. Sergeant Hipwood, a valuable man, was killed. The party were absent only twenty-seven hours, the distance from La Paz to San Antonio being nearly sixty miles. It was a brilliant affair, and highly creditable to all concerned.

In the meantime a reinforcement of two companies reached La Paz from Upper California, and Lieutenant-Colonel Burton immediately took the field, marching upon San Antonio, where he made prisoner of Pineda, the military chief. An express was sent through to inform him of the ejectment of the enemy from the valley of San José, and that he had fallen back to Todos Santos on the west coast. This intelligence had already reached him, and marching upon Todos Santos, he came suddenly upon the enemy, and, charging gallantly, routed him in all directions. Captain Naglee with a mounted company pursued those fugitives who took the coast road to the northward, while the mounted parties from the ship and Cuartel ranging from Cado

Añoto Santiago, intercepted those who were making for the gulf shore. They brought in between sixty and seventy prisoners, including the Gefé Politico and some captains, and thus ended the war in Lower California.

Official notice was then received of the armistice, accompanied with vague rumors that Lower California was not included in the treaty—a sad blow to its very best people, many of whom had committed themselves to the American cause; while the Padre Gabriel, a prisoner of Lieutenant-Colonel Burton, the prime instigator of all the troubles, a dissolute and vindictive priest, was gloating at the idea of early vengeance upon those of his countrymen who had been neutral or friendly to the Americans.

On the 20th April the Southampton arrived from La Paz, bringing down Captain Naglee with a detachment of the New York regiment, one hundred strong, who relieved Lieutenant Heywood and the naval garrison of San José, the latter embarking on board the Cyane and Southampton.

Previously to leaving, the remains of Passed Midshipman T. McLanahan, of the Cyane, who was killed whilst gallantly defending the post, were removed from the corral of the Cuartel, where, from the force of circumstances, they had been deposited during the siege (the enemy firing all the time on the funeral party while the burial service was read), to an eminence between the landing and town, where they were reinterred with military honors, and the grave enclosed by a neat railing. His funeral was attended by the officers and one hundred men from the Cyane, a portion of the garrison under Captain Naglee, Lieutenant Heywood, his late commander, his comrades of the post, and a large concourse of inhabitants, by whom he was held in affectionate remembrance.

The Cyane left San José on the 25th April, and arrived at Mazatlan on the 28th, after an absence of five months from that place, conveying back to the different ships their quotas of the garrison. The crew of the Independence with one impulse asked to cheer Lieutenant Heywood on his stepping on board of his own ship again, which they did most heartily, and well-merited cheers they were.

On the 6th May the Ohio arrived, and Commodore T. Ap C. Jones assumed the command of the squadron. On the 11th May he paid his official visit to the Cyane. As something novel and in keeping with the nature of much of their past service, he was received by the whole crew under arms as infantry, the sea-lieutenants and mid-

shipmen with their companies, the executive officer at their head. The Commodore expressed himself as highly pleased, an opinion which he reiterated in a letter directed to be read to the officers and crew. This was very gratifying to all on board, and complimentary to the high condition of the squadron he had found in the Pacific. Not the least acceptable part of this communication, greatly appreciated by the seamen whose terms of service had expired, was the hope expressed by the commander-in-chief that the ship would soon be spared to return home. She had to visit San José once more. On her return, news had been received of the ratification of the treaty of peace by the American Senate, and the ship was ordered to prepare for her return voyage. She sailed from Mazatlan on the 1st June, passing close under the stern of the flagship, which she saluted and cheered, and, squaring away, ran down and exchanged cheers with the Independence. The Congress also cheered the departure of the Cyane, which left her the senior ship on the station. The Cyane on her way down called in at San Blas, which she left on the 7th June. At this port she heard of the final ratification of the treaty of peace by the Mexican Congress. She had thus seen the beginning and the end of the war on the enemy's coast.

The Cyane arrived at Valparaiso after a good passage of forty-six days. Sailing from there on the 7th August, she arrived at Norfolk on the 9th October, making one of the shortest passages on record, having been in commission three years and four months. Notwithstanding her long blockades at anchor, and the defense of harbors, she had sailed sixty-five thousand miles.

In the different affairs in which her crew and officers participated, in the Gulf of California and on the West Coast, San Gabriel, the Mesa, Ureas, siege of San José, San Vincente, &c., she had seventeen of her number killed and wounded. On the other hand, an extraordinary immunity had attended her; but one death from sickness had occurred on board, that of a private marine belonging to another ship, and received on board from the post of San José. In a crew of two hundred and ten souls this was an extraordinary exemption, and was believed to be without precedent. It may be ascribed, under a merciful Providence, to a clean and well-kept ship, a uniform discipline, a contented spirit, and last though not least (for the ship was not without her share of sickness and epidemics), to the unsurpassed skill and ceaseless devotion of her medical officer, Surgeon C. D. Maxwell. The companion of all their expeditions, he watched over

officers and men on shore with the same solicitude that he did on board.

The crew were paid off at Norfolk, having preserved to the end their high character by showing no impatience at the delay incident to getting orders from Washington, and to laying up and securing their ship.

Although their term of service had long since expired, not a single offense was committed between the time of their arrival and that of their discharge.

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NOTES ON THE LITERATURE OF EXPLOSIVES.*

PROF. CHARLES E. MUNROE, U. S. N. A.

No. II.

Under the title "Study of the Explosive Properties of Fulminate of Mercury," Berthelot and Vieille give an account of their experiments in *Annales de Chimie et de Physique*, XXI [5], 564. Whether from a theoretical point of view or as regards its applications, the study of this substance is of great importance, since it is the most perfect type of a detonator, and is used in the fabrication of fuses and for the detonation of gun-cotton and nitro-glycerine. Owing, however, to the danger in handling it, and also to the fact that theoretical questions concerning the higher explosives have not attracted attention until of late, this substance has not previously been closely studied. The fulminate examined was extracted from the regulation caps of the Engineers, each of which held about 1.5 grams, and were made at l'Ecole d'Arras. Analysis gave

	Found.		Theory ($C_4N_2Hg_2O_4$).
†Hg . . .	71.30	Hg . . .	70.40
‡CO . . .	19.40	CO . . .	19.75
‡N . . .	9.60	N . . .	9.85
§H . . .	0.04		
	100.34		100.00

*As it is proposed to continue these notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications, trade circulars, or expert testimony in infringement cases.

†Precipitated as sulphide after solution in HCl with addition of a little $KClO_3$.

‡ Determined by volume after explosion in a closed vessel.

§ Found in the same way, but is probably accidental, and came from the grease used for lubricating the joints of the vessel.

The slight excess of metallic mercury shown in the analysis came from free metal mechanically mixed with the fulminate.

Three grams of the fulminate enclosed in a tin-foil cartridge were suspended in the centre of a steel cylinder and exploded by an electric current. The cylinder was first filled with pure nitrogen whose temperature and pressure were accurately known. Five experiments gave as a mean 234.2 cc. of gas for 1 gram of fulminate. Theory requires 235.8 cc. This gas contained in 100 volumes—

$HCN + CO_2$	0.15	
CO	65.70	Ratio 2.04.
N	32.28	
H	1.87 (accidentally present).	

This proves that mercury fulminate in decomposing follows the very simple reaction

$$C_4N_2Hg_2O_4 = 2C_2O_2 + N_2 + Hg_2{}^*$$

one equivalent (284 grams) furnishing 66.7 litres of the gas (at 0° and 76 cm). From this it is seen that the detonation of mercury fulminate does not give rise to the formation of any substance capable of undergoing a notable† dissociation under the conditions of the experiment, consequently no gradual recombination can take place during the cooling which would retard the expansion of the gas and diminish the violence of the initial blow. This explains the brusqueness of the explosion. It would still be more brusque but for the condensation of the mercury vapor. In all cases the nature of the product explains the character of the explosive blow.

During these last experiments the steel cylinder was immersed in water in a calorimeter and the heat of formation determined. They thus found for one equivalent (284 grams) + 116 cal. for a constant volume, and + 114.5 cal. for constant pressure. This quantity of heat would be sufficient to raise the temperature to 4200°.

The heat of formation of mercury fulminate may be calculated from its constituents, and is found to be —62.9. The heat disengaged in the decomposition of the fulminate then results both from the separation of its elements and the simultaneous combustion of the carbon in the oxygen. This is the result obtained in a closed

* $C_2N_2HgO_2 = 2CO + N_2 + Hg$.

† They neglect here the traces of dissociation of the carbon protoxide which, as shown by Deville, manifests itself at a red heat by forming scarcely perceptible quantities of carbon and carbon dioxide.

vessel in an atmosphere of nitrogen. In contact with air, however, carbon dioxide is formed owing to the total or partial combustion of the carbon protoxide, and this disengages + 136.4 cal., making in all + 250.9 cal. under constant pressure. But this additional quantity of heat does not increase the force of the initial blow, since it results from a subsequent combustion.

The contrary effect takes place when we mix the fulminate with potassium nitrate or chlorate. These also convert the carbon protoxide into dioxide with an evolution, at constant pressure, of + 258.2 cal. with the chlorate after the reaction,

$$C_4N_2Hg_2O_4 + \tfrac{2}{3}(ClO_6K) = 2C_2O_4 + N_2 + Hg_2 + \tfrac{2}{3}KCl^*$$

and of + 229.4 cal. with the nitrate,

$$C_4N_2Hg_2O_4 + \tfrac{4}{5}(NO_6K) = \tfrac{4}{5}CO_3K + 3\tfrac{1}{5}CO_2 + 2\tfrac{4}{5}N + Hg_2.$$

The evolution of heat is then double that produced by the pure fulminate; but the initial blow is tempered here by the phenomena of dissociation due to the carbon dioxide which renders these explosive mixtures less brusque in their effects. The temperature developed is reduced at the outset by the distribution of the heat among the more considerable mass of products.

The density of the fulminate was found to equal 4.42, being calculated from the measured pressure.

The tension developed in a closed vessel was determined in the *éprouvette*, which was used by Sarrau & Vieille in their researches on gun-cotton, and was measured by Noble *crusher* gauges. The apparatus is described at length, but the illustrations given are essential to clearness. In comparing the results obtained from introducing varying weights of the explosive in the same vessel, the ratio of the weights of the explosive to interior volume of the *éprouvette* is called the *density of the charge*.

Density of charge.	Weight of fulminate.	Pressure in kilos per square centimeter.
0.1	2.43	477
0.2	4.86	1730
0.3	7.39	2697
0.4	9.72	4272 †

* $3C_2N_2HgO_2 + 2KClO_3 = 6CO_2 + 3N_2 + 3Hg + 2KCl$
$5C_2N_2HgO_2 + 4KNO_3 = 2K_2CO_3 + 8CO_2 + 7N_2 + 5Hg.$

† Calculations from Marriotte's law, supposed applicable under these circumstances, show a pressure of at least 2070 atmospheres.

In the last experiment the lower piston was broken in three pieces, and the copper obturator was driven, in the form of fine threads, into the annular space of $\frac{1}{100}$ millimeter existing between the piston and the concentric canal. These phenomena are characteristic of the brusqueness due to decomposition through detonation.

However, if the local action with fulminate is greater than with ordinary explosives, we cannot conclude that the mean pressure developed under a given *density of charge* is also greater. It is far from it, for Sarrau & Vieille found for gun-cotton under precisely similar conditions,

Density of charge.	Pressure in kilos per square centimeter.
0.1	1085
0.2	3120
0.3	5575
0.4	8745

This statement of these relations is otherwise in accordance with those given concerning the quantity of heat and the volume of gas produced by the two explosives. These are, in general, that it is neither the volume of gas disengaged nor the quantity of heat produced which impresses on the fulminate its peculiar character and specific advantages, for it is surpassed in both these directions by many explosive bodies. The pressure under a given *density of charge* is less also for fulminate of mercury than for gun-cotton, and nearly the same as for dynamite of 75 per cent., which is less than pure nitro-glycerine.

The superiority of the power of fulminate is manifested best when in contact with a body, and it is due to three causes: the nearly instantaneous decomposition of the body by simple inflammation; the almost total absence of dissociation products, and finally the great density of the explosive. By reason of these conditions, the definite products of the reaction appear to form all at once, before the matter has had time to take a volume notably superior to that of the primitive solid. If, then, the fulminate detonates in a receptacle, in contact with the sides of the same, it develops on it, at the start, an instantaneous pressure which bears no definite relation to the mean pressure controlled by the capacity of the receptacle. Berthelot and Vieille have sought to estimate the pressure developed under these conditions of contact, and they find that the curve for the explosive substances, representing the tension in a closed vessel, tends rapidly toward an

asymptote. Admitting this, mercury fulminate with an absolute density of 4.42 will develop in contact a pressure of 48,000 atmospheres, whilst compressed gun-cotton, with a density of 1.1, such as employed for military purposes, will develop in contact only 24,000 atmospheres. Calculation will show that no other explosive known will give in contact an instantaneous pressure at all comparable to that of the fulminate. Without insisting too strongly on these numbers, it appears useful to notice them, since they mark the general relations of these phenomena. The superiority of the effects due to the explosive shock of the fulminate is explained by this circumstance joined with the absence of dissociation; nothing can resist direct contact with this explosive.

In one experiment the fulminate was deposited on the bottom of the steel calorimeter, and the mean pressure, calculated in advance, could not have been more than 50 atmospheres. Yet the steel vessel was bruised all over the surface occupied by the charge, the contours of which were found impressed on the metal.

We know that fulminate of mercury is eminently fitted for determining the nearly instantaneous propagation of deflagration (which is so distinct from inflammation, properly called), and which is indispensable for causing dynamite and compressed gun-cotton to develop their entire power. Berthelot has given elsewhere * a general theory in explanation of these characteristic effects, which refers the violence of the initial blow to the brusqueness of the successive decompositions, and also to the enormous pressure exerted at the point of contact during the course of these decompositions. These results sustain his theory and show why the fulminate of mercury is particularly adapted to provoke true detonations in other explosive bodies.

Nitric peroxide, which plays so important a part in the high explosives, exhibits such anomalies in its volume composition and vapor density as to make the study of its properties of great importance and interest, and the paper of Berthelot and Ogier in *Comptes Rendus*, XCIV, 916, on "The Specific Heat of Hyponitric Gas" is of especial value. Like acetic acid and analogous bodies the density of the vapors varies very greatly with the temperature, departing from the laws of Marriotte and Gay-Lussac. This makes the determination of the specific heat very tedious and difficult. However, they have determined the loss of heat between 200° and 26° and between 100° and

* Sur la force de la poudre, 2d edit. 1872, 165.

26°, and they have deduced for the mean specific heat of a molecule (referred to a weight of 46 grams) between 100° and 200° a number (+ 17.4) greater than the sum of the specific heats of its constituents, oxygen and nitrogen, and that the gas followed the same ratio as condensation 3 : 2 as carbonic acid, protoxide of nitrogen and the like. Between 100° and 26°, however, the specific heat is greater than between 200° and 100°. This is explained in saying that the heat disengaged between 100° and 26° represents the sum of two effects: the one corresponding to the heat lost without a change of molecular state, which may be estimated to approach somewhat the specific heat between 100° and 200°; and the other corresponding to this change of state, which is + 3 cal. 980, which is nearly equal to the heat of vaporization of the same (+ 4 cal. 300 at 76 cm). The true heat of vaporization, that is to say the heat used in the work of bringing the hyponitric gas to its theoretical density, should be defined as the sum of the heat of liquefaction and of a quantity imparted to it through all this interval. The optical properties of hyponitric gas and the progressive variation of its density accord in their general significance with the thermal phenomena indicated in this paper.

A trial has been going on for some time in the United States Circuit Court of the Southern District of New York, in which the Atlantic Giant Powder Company have sought to prove that the Dittmar Powder Manufacturing Company were infringing their rights by manufacturing and selling an explosive called Glukodine. A suit* had already been brought against the California Vigorite Powder Company, to stop the manufacture of vigorite, which had the composition of

Chlorate of Potash . . .	17.50 per cent.
Nitrate of Potash . . .	18.75
Chalk	8.75
Sawdust	11.25
Nitro-glycerine	43.75

and it was claimed by the plaintiffs that glukodine was a substance of similar nature, differing only in certain unessential particulars, and being practically a nitro-glycerine dynamite; while the defense held that it was an entirely new substance, in which the nitro-glycerine and nitro-saccharose, or the elements of each, were either united chemically or chemico-physically. In the attempt to sustain these oppo-

* This suit was dismissed by Justice Field.

site views a great mass of evidence has been taken, from which we abstract the following statement of facts observed and experiments made. Mr. Carl Dittmar describes the process for making glukodine as follows:

"I take saccharose (cane sugar) and dissolve this in anhydrous glycerine to the extent of the latter's dissolving capacity, which will vary both with the quality of the sugar and the quality of the glycerine used in the solution. The solution I then subject to the chemical reaction of a bath of the mixed acids (nitric and sulphuric acids) in their concentrated form. In the event of the formation of lumps or solidification, I add such a quantity of free solid sugar as will suffice to remove such lumps, and when these have been removed and the nitration is complete the usual alkaline solutions are applied, and they will completely neutralize the product, which is glukodine."

Glukodine is a whitish liquid fluid after the addition of free sugar, the sugar dissolving in it, and soluble in ether in all proportions. Nitro-cellulose absorbs about four times its weight of glukodine, and for the preparation of white and black glukodine this solid powder is mixed with 10–15 per cent. of free sugar, with carbonate of soda, with nitrate of soda or potash, and with wood-fibre or charcoal. The kind and amount of the various ingredients vary with the price and quality desired.

Prof. P. De P. Ricketts finds by analysis that white glukodine powder contains

Matter soluble in ether (glukodine),	36.40 per cent.
Free sugar,	8.40
Soda salts (mostly nitrate),	31.20
Nitro-cellulose,	23.36
	99.36

And that black glukodine powder contains:

Matter soluble in ether (glukodine),	34.24 per cent.
Free sugar,	8.76
Soda salts (mostly nitrate),	37.84
Nitro-cellulose and charcoal,	19.31
	100.15

Prof. Charles F. Chandler analyzed the same samples with Prof. Ricketts, and reached similar results as to all the ingredients except

the glukodine. He testifies to having found in the white glukodine powder:

Nitro-glycerine, 33.19 } instead of 36.40 per cent. of glukodine.
Nitro-saccharose, 3.21 }

and for the black glukodine powder:

Nitro-glycerine, 30.23 } in place of 34.24 per cent. of glukodine.
Nitro-saccharose, 4.03 }

Prof. Ricketts says that nitro-saccharose is a white solid substance produced by the reaction of concentrated nitric and sulphuric acids upon cane-sugar. It is very unstable, and indicates a much greater tendency to decomposition than either nitro-glycerine or nitro-cellulose. Its unstable qualities are extremely pronounced, as it decomposes even when admixed with water and while standing for any considerable time. He placed a jar containing nitro-saccharose and water of ordinary temperature in the laboratory, and after a few days the red fumes indicating decomposition were plainly perceptible. Its affinity for nitryl is slight, as shown by the fact (1) of its inconstancy, and (2) that my analysis of nitro-saccharose at different periods of time gave varying amounts of sugar. I have made no tests as to its explosiveness and as to the conditions under which it will explode, but the theoretical formula of its composition indicates its close relationship to both nitro-glycerine and nitro-cellulose. The three compared together are as follows:

Glycerine.	Saccharose (cane sugar).	Cellulose.
$C_3H_8O_3$	$C_{12}H_{22}O_{11}$	$C_6H_{10}O_5$
Nitro-glycerine.	Nitro-saccharose.	Nitro-cellulose.
$C_3H_5(NO_2)_3O_3$	$C_{12}H_{18}(NO_2)_4O_{11}$	$C_6H_7(NO_2)_3O_5$

Nitro-saccharose, however, according to the analyses of the prepared samples hereinbefore referred to, would have the formula $C_{12}H_3(NO_2)_{19}O_{11}$. This approximate identity of formulæ indicates a close resemblance between the three explosives; this is further borne out by authorities which state that nitro-saccharose has been used as the charge for percussion caps, which would again indicate its sensitiveness to shock and its great detonative qualities.

Carl Dittmar stated that nitro-saccharose is extremely sensitive to atmospheric influences, and detonates at a considerably lower degree of heat than is necessary for the explosion of nitro-glycerine. He has found it to be equally as and more sensitive to percussion or con-

cussion than nitro-glycerine, and as liable as the latter under like conditions to explode by accidental percussion or concussion, when confined in the same way as nitro-glycerine must be confined in order to be susceptible of explosion in that way. Like nitro-glycerine, it decomposes when unconfined, giving up its gases, but without explosion. It is stronger and quicker than nitro-glycerine, bearing a closer resemblance to the ordinary fulminates; in fact, so quick and energetic is its detonation, and so great is its power, and so readily is it decomposable, that for many years it was used as the charge for percussion caps, where quickness, readiness and great force of explosion are necessary requirements. Until now, however, it has been practically useless as a blasting medium, owing to certain of its characteristics which have prevented its manufacture and use upon an economical and commercial scale. As a fulminate it could be made in small quantities, but its sensitiveness to atmospheric influences and hygroscopic qualities soon drove it from the market, almost entirely if not quite so, until to-day it is regarded more in the light of a chemical curiosity than in that of a valuable and available explosive.

The difficulties encountered when manufacturing this explosive in larger quantities than necessary for small fulminating charges were these: It assumed, when undergoing the process of nitration, the consistency of a sticky mass which, when washed with water of ordinary temperature, quickly solidified, and hardened to such an extent that its thorough permeation by the alkaline wash waters and solutions which are designed and necessary to rid the compound of all superfluous and free acids was rendered impracticable, thus preventing them from affecting the entire mass, whereby free and uncombined acids remained present in the compound, greatly impairing its usefulness as an explosive medium. These free acids would, under conditions of the confinement of the compound, which confinement must needs be very close in order to prevent decomposition from the effect of warm or moist atmosphere, and in order to counteract the hydroscopic tendency of the nitro-saccharose, generate sufficient heat by gradual decomposition of the compound to induce spontaneous detonation, or detonation by the superadded heat resulting from an accidental blow or percussion. If unconfined, this gradual decomposition without detonation would wholly destroy or materially diminish the explosive force of the compound.

On the other hand, if washed with tepid and like alkaline solutions, so considerable a portion of the nitro-saccharose would be dissolved

therein and pass off with the wash waters, or so much thereof would be decomposed thereby, and injuriously affected in its explosiveness, that the yield and result would be highly unsatisfactory and unprofitable, while its hygroscopic and decomposable tendencies rendered its close confinement in air and water-tight enclosures absolute requirements.

To determine if glukodine were a mechanical mixture of nitro-glycerine and other substances or not, Mr. Thomas Volney mixed 12 parts of glycerine with 5 parts of well-dried cane sugar, and then nitrated this solution in the same way that glycerine is nitrated for nitro-glycerine.

A weighed quantity of this product was then put into an open glass vessel and placed on a bath of mercury in a cavity made in cement, resting upon the dome of a steam boiler, with steam at about 20 lbs. pressure, and kept there for 24 hours; at the end of that time nothing was left but nitro-sugar; the nitro-glycerine had evaporated. On weighing he found the nitro-sugar to be 20 per cent. of the weight of the mixture originally put into the glass. This experiment was repeated three times: in one of these he covered the glass with wire gauze, and this with cotton, which condensed the nitro-glycerine vapor; this cotton was washed with ether, which was then evaporated and left pure nitro-glycerine.

He finds after dissolving nitro-sugar in nitro-glycerine in a great variety of proportions that the greater the proportion of nitro-sugar the thicker the solution. With 3 parts of nitro-sugar to 2 parts of nitro-glycerine, the consistency is that of strained honey; with 150 per cent. of nitro-sugar we have a viscid, sticky mass like fir balsam. He states that he was unable to dissolve sugar in either nitro-glycerine or glukodine.

Dr. Henry Morton verifies Mr. Volney's experiment in the following statement: "Taking advantage of the circumstance that nitro-glycerine will evaporate readily at temperatures about 125 deg. centigrade (257 deg. Fah.) without danger of explosion, which requires a temperature of about 492 deg. Fah., I took 30 grains of glukodine (made by nitrating a mixture of 12 parts glycerine and 5 parts sugar), and placed it on a mercury bath whose temperature I maintained carefully at 120 deg. to 130 deg. C. for six hours.

"Over the vessel containing the glukodine I placed a sheet of wire cloth, and this I covered with cotton wool.

"In six hours the nitro-glycerine had all evaporated from the nitro-

sugar, which was left as a transparent gum, weighing 5.55 grs., or 18½ per cent. of the original quantity taken. A large part of the nitro-glycerine was condensed in the cotton-wool, from which it was readily dissolved out with ether, and this being removed by evaporation, left the nitro-glycerine with all its well-known physical properties and its peculiarly violent detonating quality when struck or suddenly heated to a temperature of about 490° F."

Arthur H. Elliot, F. C. S., has studied nitro-saccharose and records his results in the *Jour. American Chem. Soc.* **4**, 8, 147, Aug. 1882. He tried several methods of manufacture and recommends the following: Pure crystals of cane-sugar were reduced to a powder fine enough to pass through a 100-mesh sieve, and then dried in a water bath. 800 grams of H_2SO_4 (sp. gr. 1.84) were mixed with 300 grams of HNO_3 (sp. gr. 1.53). 95 grams of sugar were used, and one-half of it was slowly stirred into the acid mixture, and the whole allowed to cool. Then the rest of the sugar was added, and the completed mixture allowed to stand one hour, with frequent stirring. The acids were now poured off the nitro-saccharose, and the latter, when washed and kneaded thoroughly with water, weighed 135 grams. When the mass was first removed from the acid mixture it had the consistence of soft butter, but as the washing and squeezing progressed it became more and more resinous and white. A further kneading in water as hot as the hand would bear, using two lots of one litre each, and finally in water containing one per cent. of potassic carbonate, reduced the well-squeezed mass to 109 grams. This method appears to give the best results in the matter of washing, but the material slowly decomposes, the water in which it is kept becomes acid and smells faintly of hydrocyanic acid. Nevertheless the nitro-saccharose made by either of the methods used changes so slowly that he kept it under water for over a year without any great change in appearance or bulk, beyond the acid reaction mentioned above.

He tested its solubility in many different solvents, and its action toward ferrous chloride and ammonium sulphydrate, and analyzed it, and he finds (in **4**, 9, 186, Sept. 1882) that his results may be represented by the formula $C_{12}H_{14}(O.NO_2)_8O_3$ and that the substance is an octonitrate.

A new explosive has been invented by M. Petri, a Viennese engineer. The name given to it is *dynamogen*, and, according to the *Neue*

Militärische Blätter, it is likely to compete seriously with gunpowder. The inventor states that it contains neither sulphuric acid, nitric acid nor nitro-glycerine. The charge of dynamogen is in the form of a solid cylinder, which can be increased in quantity without being increased in size, by compression. The rebound of the guns with which the new explosive has been tried is said to have been very slight. It is also said that the manufacture of dynamogen is simple and without danger, that it preserves its qualities in the coldest or hottest weather, and that it can be made at 40 per cent. less cost than gunpowder. [*The Engineer*, June 2, '82]. In an article on Experiments made by the Austrian Artillery in 1880, the *Revue d'Artillerie* (XIX, 3, 242) says they have made experiments on the relative explosive force of powder and of a new explosive called *dynamogène*, proposed by Messrs. J. F. Petry and Louis Princeps. This substance is made by the aid of a prepared paper, the fabrication of which is kept secret. For firing they roll it up like a band of paper and place it in a cartridge-case. When they fired these cartridges they gave less smoke and heated the gun less quickly than powder, and also after long firing left only a slight residue, which was easily removed. Unfortunately the *brisant* effect of this compound on the gun is very considerable, and besides the accuracy of fire is much inferior to that of powder.

Two years ago, Hellhoff, of Berlin, patented a process for making explosives from crude coal-tar oils by direct nitration with strong nitric acid. The mixture of various nitro-substances thus obtained was washed and dried, then mixed with oxygenated substances. The alkaline nitrates, chlorate of potash, and the strongest nitric acid served for this purpose. Experience gained by long-continued manufacture with the aid of steam proved that the separate fractions of the crude tar oils, even those of the highest boiling point, were capable of nitration and gave a satisfactory yield of nitro-derivatives.

The question naturally arose whether the tar itself could not be nitrated and utilized for making explosives. Experiments made in this direction soon showed that the treatment of coal-tar with strong nitric acid was a very dangerous operation, that its employment on a large scale would be attended with great difficulties, and the greater part seemed to be burned up and lost. In subsequent experiments, therefore, an acid of 1.53 to 1.45 specific gravity was employed. The liquid tar is gradually stirred into the acid, the surface of the acid

becoming covered with it. After a while this layer of tar contracts on stirring and settles slowly to the bottom. In about ten minutes the mass at the bottom puffs up, and gradually changes from a liquid to a solid or pasty state. The completion of the operation can be recognized by the mass rising from the bottom and spreading itself evenly over the surface. When the acid has been all used up, the tar which is added no longer contracts and settles to the bottom. The chemical changes do not produce an excessive amount of heat, so that cooling is unnecessary.

The product thus obtained is well washed with excess of water, and the sour wash-water that remains in its pores is expressed out. The purified product is then mixed with the oxygenated bodies above-mentioned. One part by weight of the product dissolves very slowly, with the evolution of but little heat, in three parts of nitric acid, specific gravity 1.52. All these substances gave new explosive compounds of different degrees of violence. The power possessed by a solution of these new nitro-derivatives in concentrated nitric acid is shown by the fact that a small quantity of it, when exploded by a double dynamite exploder, was able to shatter an iron shell.

Owing to the varying composition of the tar it is impossible to give the exact proportions in all cases of the oxygenated substances which must be added, but in the experiments it was found that two to five parts of concentrated nitric acid, chloric acid, or four to six parts of salts, were sufficient for one part of the nitro-derivative. The great advantages offered by this process are cheapness of the material to be acted upon, the cheapness of the lighter acid used (the difference is about 60 per cent.), and finally in the quiet and regular manner in which the operation takes place, permitting of the use of more simple and less expensive apparatus, etc.

These favorable results led to further experiments upon pitch, the paraffines, etc., as well as the mineral oils. The possibility of nitrating the latter seemed probable from their great similarity to the crude tar oils. Experiment, in fact, proved that they reacted exactly alike. But the strongest nitrating agents are required to act upon the purified mineral oils used for illumination. A mixture of equal weight of the strongest nitric and sulphuric acids, or a mixture of an alkaline nitrate with sulphuric acid, was employed.

On paraffines and similar products the weaker acids are as ineffective as on purified oils. By the action of the nitrating agents mentioned upon purified mineral oils, nitro-compounds were precipitated,

of a light yellow or light brown color, having the external appearance of rancid fat. These products are difficultly soluble even in the strongest nitric acid. Pitch treated with nitric acid of 1.45 to 1.52 specific gravity gave a yellow-brown solution, and from this light yellow to brown scales separated on washing with water. The oil and pitch from wood-tar were treated with the weaker acid (1.45), and those from brown coal and stone-coal with the stronger acid (1.52). The products thus obtained are easily soluble in strong nitric acid with slight evolution of heat. These nitro-compounds when mixed with oxygenated bodies also form powerful explosives, but the quantity of the latter used must be two to four times greater than that added to nitro-derivatives of tar. There is no special advantage in working these materials as compared with tar or even the tar oils, for a high grade of acid must be used, while the increased quantity of oxygenated salts raises the price still higher. Still, this process is of some importance in so far as pitch is concerned, since the price of tar is likely to increase as more uses are found for it.

All the special products of the distillation of coal having been found capable of being converted into explosives by nitration, it only remained to try an experiment on the original materials, coal and peat. Wood was excluded from the list, for its conversion into an explosive (pyroxyline) had already been accomplished by Trauzl. It was found that the direct conversion of coal into an explosive by extracting the nitro-products would involve very expensive and tedious manipulations. After numerous unsuccessful experiments in which the product was either completely burned up or the coal was but slightly acted on, we were induced to try a gradual nitration. The coal, in form of a fine dust, was first treated with weak nitric acid, specific gravity 1.40 to 1.48; the weight of acid required was ten times that of the coal used. When stone-coal was introduced slowly into the acid the rise in temperature was inconsiderable, and some hyponitric acid was formed. The action was much more violent in the case of brown coal, and least so with wood-coal. After the operation with any coal, a large portion of the material to be nitrated remained apparently unaffected and formed a thick sediment on the bottom of the vessel, while the nitro-product was dissolved in the acid layer above and imparted to it a light brown color—with brown coal nearly a tar color. When this fluid layer was well washed with water the nitro-product was thrown down as a fine brown powder. This precipitate was filtered out and washed repeatedly until the wash

water was no longer acid. The sediment was also washed several times to remove the exhausted acid, then dried and finally treated with the most concentrated acid. It separated into two layers; the liquid one was treated just as before described to obtain the nitro product suspended in it. Again the precipitate was brown, either light or dark. The solid residue was again washed and dried, then treated with the most powerful nitrating agents. In this way we succeeded in converting nearly all the brown coal and stone-coal into nitro bodies, as well as the larger portion of the wood-coal. The yield was scarcely sufficient to compensate for the large consumption of acid, especially with the wood charcoal and coke. All the nitro-products obtained are nearly alike in color, state of aggregation, and other properties. They are insoluble in water, soluble in alcohol, and the most concentrated in nitric acid, and burn with strong aromatic odor. They are heavier than water.

The results of the experiments made on peat were considerably more encouraging, different kinds being tried. A firm, solid kind called "bog peat" (*Moortorf*), from Luneburg, was tried after a small test had shown that the reaction would not be too violent. It was first subjected to the action of equal parts, by weight, of the strongest nitric and sulphuric acids for several hours. The substance changed color from dark brown to dark red. Ignited in the air it burned with a lively flame and strong aromatic odor. When soaked in a solution of chlorate of potash and dried, it formed a powerful explosive. If the same peat was well pounded before the nitration, so that the humus substance was separated from vegetable fibres, and a larger surface was exposed to the powerful action of the acids, the earthy humus constituents were converted into a dark brown, liquid, sticky nitro-body, having the external characters of that obtained by nitrating the heaviest tar oils. Its action when mixed with oxygenated bodies is also just like the latter. The other nitro-substance, formed from the finely divided fibres left in the dry distillation that attends the formation of peat, yields an explosive without any admixture of an oxygen-bearing salt. In the open air it burns very rapidly, leaving a slight carbonaceous residue.

Peat containing animal admixtures acts just like this bog peat. Peat that seemed to be of later formation would not bear the action of concentrated acids. There was a violent evolution of hyponitric acid, and in spite of the most careful cooling the heat became so great that there was danger of its reaching the ignition temperature of the

nitro-derivative, so that the process had to be interrupted. The same peat was then mixed with ordinary commercial nitric acid, specific gravity 1.35, and as the action of this acid was scarcely perceptible, concentrated acid was gradually added until the process began to be quite violent. The acid had then been brought up to a gravity of 1.45. After the reaction had gone on for several hours with careful cooling, the product was washed and dried. This is also an explosive without the admixture of the oxygenated body, but not so strong as that made from bog peat with the stronger acids. Others of the newly prepared nitro-derivatives, especially those from the crude tar oils by repeated nitrations, form explosives alone; but they are always weaker than when mixed with oxygenated bodies.

The manufacture of explosives from peat, owing to the cheapness of the material and its wide dissemination, as well as the simplicity of the process, is doubtless an important step in advance.

The chief characteristics of the newly-prepared nitro-substances are the following: The specific gravity of all is very nearly that of water. They all possess a powerful aromatic odor, resembling the fruit ethers, which is particularly noticeable on burning them. All solutions of these substances have a strong refractive power. The greater part of them are soluble in the strongest nitric acid, as well as in alcohol; they are all insoluble in water. In the open air they all burn with a bright, but more or less smoky flame. Their molecules are so unstable that they can be exploded alone, or, mixed with oxygenated substances, by simple ignition.—*Deutsche Industrie-Zeitung*, No. 36; *Oil, Paint and Drug Reporter*, **22**, 927, Oct. 25, 1882.

The second article* on "Dynamite and its Manufacture," being a description of the works at Arden, appears in the *Engineering* for June 9, 1882, and we will here abstract from both of them. In comparing the merits of nitro-glycerine and dynamite as to safety, reference is made to the accident at Newcastle-on-Tyne, where the town-clerk, sheriff, and other officials undertook to destroy a seizure of nitro-glycerine on the town moor. A policeman was employed to break open the cans with a pick, an explosion ensued, and he and most of the spectators were killed.

This company (The British Dynamite Company) is the only one now operating in the United Kingdom, but owing to the fact that the Privy Council has refused to renew the monopoly, on account of the

* Proc. Nav. Inst. Vol. VIII, p. 298.

great profits, rival companies have been organized and will soon enter into a competition which will probably result in a fall of prices. The advantages of the site on the Ayrshire coast are cheapness of the land, freedom for manufacture with a minimum of danger within, and no valuable property without, the factory; direct linking with railway system of the country; good facilities for loading sea-going vessels direct from the magazine; ports in the vicinity where vessels may lie until wanted.

The nitric acid for the manufacture of the nitro-glycerine is made on the premises; the sulphuric acid, the fuses, and the detonators are made at the factory at Westquarter, Stirlingshire. Formerly sulphuric acid was transported in glass carboys, which were both bulky and fragile, but now it is brought in large, long, flattened iron tanks, it having been found that iron of moderate thickness will resist the action of sulphuric acid for a long time. This has resulted in considerable economy in the cost of conveyance. The converting houses are placed on elevations and the acids and glycerine are brought up a tramway, while the nitro-glycerine flows down to the kieselguhr kneading houses through leaden troughs. The process of manufacture of the nitro-glycerine is too vaguely described to bear repeating, but the product is spoken of as a "muddy, yellowish fluid." All the nitro-glycerine produced is made into dynamite upon the day of its manufacture. The nitro-glycerine and kieselguhr are mixed by hand. The cartridges are filled by women. This is accomplished by the use of a four-sided hopper, fixed to the side of the building, and terminating downward in a sloping point, to which a small brass tube is affixed. The size of this tube regulates the size of the cartridge. Loose dynamite from the box beside the worker is spooned into the hopper as occasion requires. With the left hand the worker seizes a water-tight cartridge paper, and wraps it round the brass nozzle. With the right hand she rapidly moves a lever up and down, which presses the dynamite into the cylinder and cartridge. The cartridges are packed in water-tight paper and put in boxes containing fifty pounds each. The buildings in which the filling is done are built in accordance with the Explosives Act, and the maximum number of persons and amount of dynamite allowed in each is fixed by the government inspector. Great care is manifested in all the operations, and the works are carefully policed, so that in the ten years of operation no workman has lost his life through a casualty at the works.

The total quantity of dynamite produced each day is from four to six tons, and the selling price for years has been £200 per ton. It is sent to all parts of the world except the United States. For the purpose of transportation the company own a couple of steamers and a smack. The steamer Maggie, with a cargo of fifty tons of dynamite and many thousand detonators, successfully weathered a gale on a voyage from the Clyde to London.

"As a rule the quality of dynamite manufactured is very uniform. One may stand by a foot-pound recoil apparatus, which swings a large mortar, and is self-adjusting, and observe a dozen one-quarter ounce cartridges, taken from different parcels on different days, perform precisely the same amount of work, namely, about 900 foot-pounds, or nearly half a ton, lifted one foot high."

About 300 yards from the dynamite factory the company have erected works for the manufacture of nitro-gelatine, which as yet is not much known as a blasting agent, but which has rending properties fifty per cent. stronger than dynamite. Success is attained in the mixing of the nitro-cellulose and nitro-glycerine, to form the nitro-gelatine, so thorough and so well proportioned that the gelatine leaves no stain or either the hand or on paper. Under these conditions there can be no exudation. At present only about half a ton per day of the new explosive is produced, but arrangements are maturing for the manufacture of a much larger quantity.

It is in bad taste for the writer to accuse the manufacturers of the United States of piracy, while in the same sentence he states that, after long litigation, our courts have declared the Nobel patent virtually invalid.

The method of submarine blasting devised by Major Johann Lauer of the Austrian army, referred to in our last number,* is described at length in *Mitt. Artil. Genie-Wesens*, Part I, 1882, p. 1, and also quite fully with drawings in *Engineering* for May 19, 1882. Two different explosives were used: new dynamite No. 1, and gelatine dynamite. The first was composed of fifty-eight per cent. of nitro-glycerine, two per cent. of gun-cotton, and forty per cent. of powder mixture consisting of seventy per cent. potash saltpetre and thirty per cent. of sawdust. The gelatine dynamite (new gelatine) was composed of seventy-eight per cent. of nitro-glycerine, two per cent.

* Vol. VIII, p. 298.

of gun-cotton and twenty per cent. of the powder mixture. The charges were in quantities of 0.25 kilo and 0.50 kilo in paraffined paper, and 0.3 gram exploders were used for the new dynamite, and 0.1 gram for the new gelatine.

In the *Mém. Soc. Ingénieurs Civils*, Feb. 28, p. 238, M. Brunet gives the results of his work in the removal of submarine rocks at Cette, L'Orient, and Carthagène. He used on the average one kilo of dynamite for ten cubic metres of rock of ordinary hardness. At Frioul they disengaged, in one operation, a volume of 10,000 metres with 1000 kilos of dynamite, used in two mines.

In a review of L. Tetmajer's work entitled "Die Nobel'schen Nitroglycerin-Präparate," the *Mitt. Art. Genie-Wesens*, 5 and 6, 1882, B. A. 29, extracts the following table:

EXPERIMENTS MADE WITH TRAUZL'S MEASURE FOR EXPLOSIVE FORCE.

Substance.	Composition.	Volume in cm^3.	Relative Strength.
Nitro-glycerine	Water free.	1380	100
Explosive gelatine	93 per cent. nitro-glycerine. 7 " collodion gun-cotton.	1350	100
Gelatine dynamite, No. I.	58 per cent. nitro-glycerine. 2 " collodion gun-cotton. 28 " saltpetre. 12 " cellulose.	960	70
Gelatine dynamite, No. II.	38.8 per cent. nitro-glycerine. 1.2 " collodion gun-cotton. 45 " saltpetre. 15 " cellulose.	710	52
Kieselguhr dynamite, No. I.	75 per cent. nitro-glycerine. 25 " kieselguhr.	950	70
Dynamite, No. III	25 per cent. nitro-glycerine. 75 " saltpetre powder.	550	40
Fulminating mercury	Alone.	300	22

Trauzl's method is by means of the lead cylinder described some time since in these Proceedings.* In these experiments the cylinder measured 20 cm. in diameter and 20 cm. in height. The charge consisted of 20 grams of the explosive and 0.4 gram of fulminating mercury for an exploder. From the table we see that as

* Vol. V, p. 25.

the results of these experiments the force of the dynamites No. I is to that of explosive gelatine as 1 : 1.42. In driving the Pfaffen Spring tunnel, where both of these explosives were used, it was found that to remove one cubic meter of rock required of dynamite 3.28 kilos, and of explosive gelatine 2.28 kilos. In a larger tunnel, to remove the same quantity of rock required of dynamite 3.80 kilos, and of explosive gelatine 2.51 kilos. Here the consumption of gelatine to dynamite for the same work was as 1 : 1.43 or 1 : 1.51.

The *Mém. Soc. Ingénieurs Civils*, May, 1882, p. 629, contains a report by M. Murgue upon the regulations to be issued concerning the arrangement and control of magazines for dynamite, in which it is urged that the tax upon dynamite in France, which now amounts to one-half the value of dynamite No. 3, should be reduced.

The dynamite cartridges heretofore issued to the cavalry and cossacks in Russia for destroying railroads and telegraph lines were withdrawn June 25, 1881, and replaced by gun-cotton cartridges. (*Mitt. Artil. Genie-Wesens*, Part 3–4, 1882, Kleine Notizen 59.)

In the *Engineering*, February 24, 1882, is an account of a launch of a large screw steamer at Kinghorn, Scotland. The launch was accomplished by means of a number of charges of dynamite placed in the wedge-blocks along the sides of the keel. These were exploded one by one, beginning at each end, and when the last of the wedge-blocks were removed, hydraulic power was applied, and the vessel glided off the ways in excellent style.

Antimony and certain other of the metals when deposited in certain states exhibit such phenomena of heat and light when struck or heated as to be termed explosive. In the *Comptes Rendus*, XCIV, Deville and Debray treat of such a substance under the title "Note on some Explosive Alloys of Zinc and the Platinum Metals." Rhodium, ruthenium, iridium and osmium all combine to form such alloys. Platinum and palladium do not. When the osmium alloy is heated to 300° C. it takes fire immediately, nearly with explosion, and gives off fumes of zinc oxide and osmic acid. The phenomena attending the change of state of the iridium alloy is so marked as to serve to detect the presence of as small quantities as one to two per cent. in the presence of platinum.

The special committee to test the explosive qualities of xerotine siccative, which comprises among others Professor Abel and Colonel Majendie, have been engaged at Chatham in the necessary experiments. Operations were first undertaken to test the force of dynamite, and for this purpose the Enterprise, one of the obsolete armor-plated wooden ships, was turned over to the committee. In one of the rooms a small quantity of dynamite was exploded, with the result of completely shattering all the rooms in the vicinity and injuring seriously other parts of the vessel. Other experiments were made by placing a small quantity of xerotine siccative in an iron cask and shaking the latter occasionally at stated intervals for twenty-four hours. A train having then been laid and fired, no explosion followed; but upon a light being applied there was a loud explosion. Further experiments were made by placing the siccative in water, but the latter appeared to have no effect upon it, as the siccative readily exploded when ignited.—(*Iron*, Feb. 10, '82.)

In a recent lecture on some dangerous properties of dusts Professor Abel said that many experiments were tried with sensitive coal-dust from Seaham and other collieries for the purpose of ascertaining whether results could be obtained supporting the view that coal-dust, in the complete absence of fire-damp, is susceptible of originating explosions and of carrying them on indefinitely, as suggested by some observers, but although decided evidence was obtained that coal-dust when thickly suspended in the air will be inflamed in the immediate vicinity of a large body of flame projected with it, and will sometimes carry on the flame to some small extent, no experimental results furnished by these experiments warranted the conclusion that a coal-mine explosion could be originated and carried on to any considerable distance in the complete absence of fire-damp. Some experiments made in a large military gallery at Chatham showed that the flame of a blown-out shot of 1½ lbs. or 2 lbs. of powder might extend to a maximum distance of twenty feet, while in a very narrow gallery, similar to a drift-way in a mine, the flame from corresponding charges extended to a maximum distance of thirty-five feet. These distances are considerably inferior to those which flame from blown-out shots has been known to extend, with destructive results, in coal mines, and there appears no doubt that, in the latter cases, of which the lecturer gave examples, the flame was enlarged and prolonged by the dust raised by the concussion of the explosion. In the presence of only

very small quantities of fire-damp, dust may establish and propagate violent explosions; and in the case of a fire-damp explosion, the dust not only, in most instances, greatly aggravates the burning action and increases the quantity of after-damp, but it may also, by being raised and swept along by the blast of an explosion, carry the fire into workings where no fire damp exists, and thus add considerably to the magnitude of the disaster.—(*The Engineer*, June 23, '82.)

In an article on Modern Artillery, *Engineering* of June 16, 1882, says: "From the results obtained by the Government Committee on Explosives, and the researches of Abel and Noble on fired gunpowder, it became apparent that a high initial velocity of the projectile, together with its attendant advantages of flatness of trajectory, accuracy, power of penetration, and length of range, could only be satisfactorily obtained by generating in the bore of the gun a large quantity of gas at low maximum tension or pressure. The production of a large quantity of gas can only be effected by using large charges of powder. A reduction of the maximum pressure may be secured by using either very slow burning powder, which becomes converted into gas at a much lower rate than is the case with the powders already in use; or when using the latter their destructive action may be modified by allowing the charge to expand in a chamber very much larger than is absolutely necessary to contain it. The latter method is technically known as air spacing. It is evident that a combination of both these devices is possible. The immediate result of the employment of either or both is to necessitate the use of very long guns, so as to keep the projectile in the bore under the influence of the propelling power of the gas for as long a time as possible, thus counteracting, or more than counteracting, the want of high initial pressure. The whole result may be described as follows: "It has been found possible by the use of very slow burning powder, or of quicker burning powder duly air-spaced, and expanded in a very long bore, to about double the power of ordnance, weight for weight, and such a result does not seem to point to any finality in the path of artillery."

Col. Maitland, Superintendent of the Royal Gun Factories, Woolwich, has been lecturing before the Portsmouth Military Association on "Recent Advances in Gunmaking," and before the Society of Arts on "Modern Ordnance." From the reports in *Iron* (Jan. 20

and Feb. 17, 1882) we make the following abstracts: While the advocates of breech-loading as against muzzle-loading are right, the arguments they advance are for the most part fallacious. The real cause which has rendered breech-loading an absolute necessity is the improvement which has been made in gunpowder. The slower the combustion of the powder the less the difference in the pressures exerted at the breech and at the muzzle, and the greater the advantage of lengthening the bore, and so keeping the shot under the influence of the pressure. Hence all recent improvements have tended towards larger charges of slower burning powder and increased length of bore; and it was evident the longer the bore the greater the convenience of putting the charge in from behind. Another advantage of the new system was the facility afforded for enlarging the powder chamber of the gun, so that a comparatively short, thick cartridge might be employed without any definite restriction due to the size of the bore. Again, a shot loaded from the front must be smaller all over than the bore, or it would not pass down to its seat. A shot thrust in behind, on the contrary, might be furnished with a band or sheath of comparatively soft metal larger than the bore. The gas, then acting from the base of the projectile, forces the band through the grooves, sealing the escape in a very satisfactory way, centring the projectile and to a great extent mitigating the corroding effects of the gas. Artillerists were aware that the effect of the resistance offered by the band on the powder was to cause more complete combustion of the charge before the shot moved, and therefore to raise the velocity and the pressure.

In gun construction it should not be overlooked that the motive power is powder, and the purpose to be accomplished a hole in an armor-plate, perhaps a breach in a concealed escarp, or destructive effect on troops. No single gun is capable of realizing more than one result in the highest state of excellency. For armor-piercing a gun should have a large chamber, and a comparatively small bore of great length. For breaching fortifications a large bore without great length and no enlarged powder-chamber, and for use against troops, with shrapnel, a gun intermediate between these is required. In conclusion, Colonel Maitland remarked that there were certain axioms which were known from experience. The length of the powder chamber should not be more than three and a half times the diameter, because with longer charges the inflamed powder-gas was apt to acquire rapid motion and to set up violent local pressures. The

strength of a heavy gun should not be less than about four times the strain expected. In speaking of the benefits resulting from the employment of slow burning powders, the lecturer showed by experiment how the enlargement of the powder grains reduced the rate of combustion, and imparted their influence gradually to the projectile as it moved forward in the gun. After the lecture before the Society of Arts, Professor Abel spoke on the subject of gunpowder development.

Iron (February 24, 1882), speaking of recent experiments at Woolwich, says Colonel Maitland has taken a new departure in gunnery by giving up air-spacing as an unprofitable expedient. Having found by repeated trials the description of slow-burning powder best adapted to his requirements, he has designed a contrivance for retaining it in the chamber of the gun until the powder is sufficiently fired to set up a pressure of about two tons per square inch on the base of the shot, which then starts at a bound, its speed being accelerated until it leaves the gun by the pursuit of the powder-gases. The retention of the shot is accomplished by a ring of metal fixed around it at the base, and so regulated as to size that it will, when placed in the breech, be a trifle larger than the bore through which it has to pass. According to the resistance which it affords will be the period of retention. It has been demonstrated by experiments with field gunpowder that in a very strong vessel the powder may be ignited and converted into gas, but yet held under subjection for an unlimited time. The retention ring is made to surrender at a given pressure, and requisite conditions for the attainment of maximum velocities thus appear to have been realized. With the 10.4-inch gun a 462-pound shot has been fired at a muzzle velocity of 2275 feet per second, equivalent to 16,500 foot-tons, but as the powder charge was somewhat in excess of the service allowance, it is fair to reduce the velocity by one hundred feet. It will even then be far in advance of the speed attained under former conditions. The improvement has been shown in a competitive trial between the two experimental guns of forty-five tons, that of Elswick with the air-spaced chamber, and that of Woolwich with the retention ring. The former, with 350 pounds of powder (rather above its service charge), discharged a 700-pound projectile at a velocity of 1900 feet per second; the latter loaded with 400 pounds of powder and a similar 700-pound shot recorded a muzzle velocity of 2120 feet. These figures represent in energy

respectively 17,500 and 20,800 tons per foot, and the advantage in an attack upon armor-plates may be assessed in the same proportion.

The *Mitt. a. d. Gebiete d. Seewesens*, X, 149, describes a new powder made at the powder mills of Murcia, Spain. The mixture consists of 74 per cent. saltpetre, 16 per cent. carbon, and 10 per cent. sulphur. The form and size of the grain as well as the density vary with the calibre. For the bronze and steel 8 and 9 cm. guns it is in irregularly-shaped 6–10 mm. grains of 1.664–1.667 density. For the 14 cm. bronze and 15 cm. steel, 7-channeled prismatic powder of 1.64 to 1.69 density, and containing one per cent. of moisture, is used. The prisms are 25 mm. high and weigh 38 grams. The six sides of the ground-plan have a length of 20 mm., and the conical perforations taper from 4.8 down to 4.4 mm. The axes of the six outside perforations are 11 mm. distant from the axis of the central perforation. See also *Revue d'Artillerie*, XIX, 5, 464.

The new rules regarding the proofs for powder, for the Italian army, were approved by the Minister of War, March 9, 1881. The regulation powders are classified as follows:

Progressive Powders. These new powders, made at the Fossano powder mills, are intended for the new breech-loading siege (field and coast) guns. The grains are in the form of irregular rectangular prisms. For guns of medium calibre, that is to say of 12 cm., 15 cm. and 19 cm., the size of the grain varies between 20 and 24 millimetres; the number of grains to the kilogramme between 140 and 150, and the real density between 1.71 and 1.74.

For the 32 cm. gun the grains are from 43 to 53 mm. on the side; the number of grains to the kilo varies between 42 and 50, and the real density between 1.77 and 1.80.

Lastly, for the 45 cm. gun the grains are from 54 to 60 mm.; the number of grains to 10 kilos varies from 44 to 46, and the real density between 1.75 and 1.78.

Cubical Powder. This powder has already been used for some time for the 24 cm. gun, and also for firing rupturing projectiles in the 16 cm. G. R. C. muzzle-loading gun. The grains are nearly cubical, with rounded edges, varying in size from 9 to 11 mm.; the number of grains to the kilo is between 485 and 515, and the real density between 1.77 and 1.80.

Powder of 7 to 11 mm., being for breech-loading field guns of 7 to 11 mm., is in angular grains. The number of grains to the kilo is between 2200 and 2600; the real density 1.66 to 1.68.

The progressive powder not being suitable for small charge in guns of medium calibre they have substituted the 7 to 11 mm. powder, since ordinary cannon powder, which has been tried, has not given good results.

Ordinary Cannon Powder. This will be used for the new breech-loading mortars of 15 and 21 cm. and the *mortier rayé* of 15 cm. ret.; also for the 7 cm. mountain howitzers and all muzzle-loading guns of the old type, and also for all shells except those used in the breech-loading field guns and mountain howitzers. The grains are lamellar of 0.7 mm. to 1.5 mm. in size; real density 1.70; gravimetric density .860 to .910; number of grains to the gram 900 to 970.

Musket Powder is to be used for the cartridges for muskets, and also for the charging of all shell and shrapnel used in breech-loading field and mountain guns. The grains are lamellar of 0.4 mm. to 0.7 mm. in size; real density 1.67 to 1.69; gravimetric density 0.830 to 0 880; number of grains to the gram 4550 to 5000.

The composition of all these powders is the same, being 75 per cent. of saltpetre, 15 per cent. of carbon, and 10 per cent. of sulphur; the powders made before 1873 have different proportions. All the powders are made by the use of the drum and hydraulic press. For the *progressive* powders the ternary mixture, after having been pressed, is mixed, in a moist state, with a determined quantity (25 per cent.) of dry grained and polished powder. After granulation all these powders are polished strongly and covered with graphite.

After a preliminary examination each species of powder is subjected to the following tests: Verification of the size of the grain; measurement of the real density (and for musket and cannon powder the gravimetric density); measurement of the initial velocity; measurement of the pressure (for large grained powder only). A table of the tests they must satisfy is appended. *Revue d'Artillerie*, **19**, 4, 343. *Vide* also *Giornale d'Artiglieria e Genio*, 1882, pp. 447 and 468.

For the classification of powder in Holland see *Mitt. Artil. Genie-Wesens*, Part 5 and 6, 1882, Notizen, p. 125.

Die Moderne Spreng-technick is the title of a pamphlet of 48 pp. 8°, by Robert Krause, published by G. Knapp, Leipzig, 1881, which

treats of the use of high explosives in blasting, describes, with illustrations, the way in which the fuses are to be applied and the machines employed for firing them, discusses the question of the area of explosive effect, and gives a full account of implements employed in drilling.

U. S. Census Bulletin, No. 286, on the manufacture of chemicals, states that 3,039,722 pounds of nitro-glycerine, having a value of $1,830,417, were manufactured in the United States in 1880.

In *Iron* (Feb. 17, 1882) in an article on "Accidents in Mines," Dr. C. Le N. Foster is quoted as showing that the use of gunpowder in mining in some districts was steadily on the decrease. Amongst eighteen mines he found that where, in 1873, 217,389 lbs. of powder were used, in 1878 only 140,869 lbs. were consumed. During the same period the use of dynamite had increased from 19,159 lbs. to 88,922 lbs. Tonite had also grown in favor, and from 1875, the first year of its employment, when 100 lbs. were consumed, the sale of this explosive had extended considerably.

The Oil, Paint and Drug Reporter, Sept. 6, 1882, 551, reviews the chemical industries of Italy, from which we learn that the sulphur trade is the most important of all these industries both as regards the total production and the number of workmen employed therein. At present there are in all about 300 sulphur mines that are being worked, of which 275 are in Sicily, 20 in the Romagna, 3 in the Neapolitan States, and 2 in the former Papal dominions. It is nearly all worked in the most primitive way, by fusing the sulphur minerals with burning sulphur, which causes an average loss of about 50 per cent. of all the sulphur made in Sicily, and 43 per cent. elsewhere. Other methods of working it, such as using closed iron smelting cylinders, or superheated steam, have only been introduced in very few works.

The total quantity of sulphur produced annually for the last few years has been 400,000 tons, worth nearly eight million dollars; 21,000 workmen found employment in this trade.

The manufacture of potash saltpetre is carried on at present at two large factories in Sampierdarena and Genoa, the latter of which is under the control of the government. It is made exclusively from Chili saltpetre by double decomposition with German chloride of potassium. The saltpetre beds of former times have everywhere dis-

appeared. Besides the above-mentioned saltpetre works, a large portion of the numerous gunpowder factories make all the saltpetre they need by the same process.

For the manufacture of powder there were in Italy not long since not less than 250 powder mills, of which not many more than 100 are now running. With the exception of a few larger establishments they drag out, on the average, a miserable existence. There is an import duty of $30 per 220 lbs. on gunpowders, so that Italian manufacturers have the privilege of putting on the market a dear and generally a very poor article. At the end of 1870 there were four dynamite factories in Italy, only one of which, that in Avigliano, is still in operation.

In an article on the Productions of the Artillery Establishments in Russia in 1879 (*Revue d'Artillerie*, XIX, 2, 175), we find that the cartridge factory at St. Petersburg made 125,329,000 cartridges and 80,000,000 primers for the Berdan musket, 30,000,000 primers for the needle gun, 2,000,000 slow matches, 595,000 time fuses, 547,000 percussion fuses, and 258,325 fuses of the Prussian model.

At the powder mills of Okhta, Chostka and Kazan 2,784,700 kilos (6,126,494 lbs.) of new powder have been made, and at Okhta and Chostka 294,858 kilos (648,687.6 lbs.) of old powder have been reworked.

The fuse factory at Nikolaïev has furnished 4500 2-inch war fuses, 5510 3-inch signal lights, 150 incendiary fuses, 300 life-saving rockets, and 300 pyroxyline fuses. — *Vide.* also *Mitt. Artil. Genie-Wesens*, Part 1, 1882, Notizen, p. 29.

Bulletin Edison Electric Light Co. No. 14, p. 15, Oct. 14, 1882, announces the installation of the Edison plant at the Government Powder Manufactory at St. Chamas, France. The officials have expressed themselves as well satisfied with its working

NAVAL INSTITUTE, BOSTON BRANCH.

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COMMODORE O. C. BADGER, U. S. N., in the Chair.

TIDES: THEIR CAUSE.

By CIVIL ENGINEER U. S. G. WHITE, U. S. N.

The subject of this short paper is one which has received much attention, and many theories and reasons have been given therefor, the principal object being to account for the upheaval of the water on the side opposite to the attracting body as well as upon the side adjacent.

My attention was called to this subject some time since by an extract from an article on tides and their cause, published in the *Popular Science Monthly*, which criticised the accepted theory very severely, and, as I thought, very justly; but there was one thing contained therein which I could not accept, and of which I had never heard before, viz. "It has been proved experimentally that all bodies on the surface of the earth are heavier at midnight than at any other hour of the twenty-four; and that when new moon occurred at midnight this weight was very much increased."

Now this fact may have been proven as alleged, but I do not believe it. In my opinion the fact that there is a tide on the side of the earth opposite the attracting body is the best refutation of the assertion.

Observations upon the tides show conclusively that there are two tide waves, the lunar and solar, and that for certain relative positions of the sun and moon these waves conspire and at others they are opposed. The reasons and conditions necessary to cause these results, together with the intermediate stages of the tide, I do not propose to enter into. I will simply premise that the observed tide is the resultant of two separate and distinct tides, the solar and lunar, and that

both of these are the result of universal gravitation, are entirely similar, but different in amplitudes and are the effects of identical causes.

In discussing this question I will take up the solar tide alone, and will endeavor to show ample reason for a tide on the side of the earth opposite the sun, and will also attempt to show that any body on the earth's surface is, from the sun's attraction, lighter at midnight than at any other hour of the twenty-four, excepting midday, and also that at these hours a body on the surface of the earth is, in regard to its weight, unaffected by solar attraction. It is well known that the earth, under the action of the sun's attraction, moves about the sun in an elliptical orbit of small eccentricity; the centre of inertia of the sun and earth, taken together, being situated at one of the foci. This last is subject to the modification that such would be the fact without the perturbating influences of the other members of the solar system, but in considering this subject these influences can be ignored as having no appreciable effect upon the tide.

By Kepler's first law, the sun's attraction is the centripetal force which causes the earth to follow its orbital path, and its direction is that of the line joining the centres of inertia of the sun and earth, and a discussion of the equations representing the laws of central forces as applied to the earth shows that this attraction or centripetal force is the resultant of the reactions of two forces, one in the direction of the radius of curvature of that part of the orbit in which the earth is found, and the other at right angles thereto—the first is the reaction of the centrifugal force which acts from the centre of curvature, the second is the reaction of the inertia of the earth in the direction of the tangent to the orbit.

Now suppose the circle A, B, C, D (Fig. II) to be a great circle cut from the surface of the earth by a plane passing through the centre of the sun S, and suppose any unit of mass on this great circle, as E, to be assumed: Let

$d =$ distance from centre of sun to centre of earth.
$z =$ " " " to unit of mass E.
$\varphi =$ angular distance of unit of mass from sun.
$\theta =$ angle at sun subtended by radius to E.
$r =$ radius of earth.
$m =$ mass of sun.
$k =$ attraction of a unit of mass at a unit distance.

Now the intensity of the attraction of gravitation varies directly as the attracting mass and inversely as the square of the distance, therefore the sun's action on the unit of mass E is represented by

$$\frac{mk}{z^2}$$

but $z^2 = d^2 + r^2 - 2dr \cos \varphi$, and, substituting this value in the above expression, we have

$$\frac{mk}{d^2 + r^2 - 2dr \cos \varphi}$$

The sun's attraction for the earth, as a whole, is made up from the attraction for the units of mass separately considered, and if the attraction for any unit of mass, as E, be resolved into two components, one parallel to the line joining the centres of the sun and earth, and the other perpendicular thereto, the first will be the component of the centripetal force acting upon the earth due to this unit. As shown before, this component is the resultant of the reaction of the centrifugal force and the inertia of the unit of mass, and is neutralized by them. This component is equal to

$$\frac{mk \cos \theta}{d^2 + r^2 - 2dr \cos \varphi}$$

The component at right angles to this first is represented by

$$\frac{mk \sin \theta}{d^2 + r^2 - 2dr \cos \varphi}$$

and its line of direction is always towards the centre of the earth, indirectly. Resolving this force into two components, one in the direction of radius, and the other perpendicular thereto, we have two components represented by the following expressions:

$$\frac{mk \sin \theta \cos \varphi}{d^2 + r^2 - 2dr \cos \varphi}$$

$$\frac{mk \sin \theta \sin \varphi}{d^2 + r^2 - 2dr \cos \varphi}$$

The component represented by the first of these expressions is the one perpendicular to the radius at E, or tangent to the earth, and simply tends to impress upon the unit of mass E a motion of translation in its line of direction and cannot in any way influence the weight or specific gravity of E.

The other component represented by the second expression has

its line of direction towards the centre of the earth, and therefore impresses itself upon the unit E and thereby adds the amount of its intensity to the weight thereof. The intensity of this component is a function of the angles φ and θ, and depends upon them for its value. θ is also a function of φ. By assigning different values to φ, deducing the corresponding value of θ and substituting in the expression, the intensity of this component for different positions of the unit E can be found.

Suppose

$$\begin{aligned} \varphi &= 0 \\ \therefore \quad \theta &= 0 \\ \sin \varphi &= 0 \\ \cos \varphi &= 1 \\ \sin \theta &= 0 \end{aligned}$$

Substituting these values in $\dfrac{mk \sin \theta \sin \varphi}{d^2 + r^2 - 2dr \cos \varphi}$ and it reduces to zero, showing that at that point of the earth's surface immediately adjacent to the sun, the weight of a body is entirely independent of the sun's attraction; that it is neither increased nor diminished thereby.

Making

$$\begin{aligned} \varphi &= 90^\circ \\ \theta &= \text{sun's horizontal parallax (its maximum)} \\ \sin \varphi &= 1 \\ \cos \varphi &= 0 \end{aligned}$$

$\sin \theta$ is finite and positive.

Making these substitutions and the expression reduces to $\dfrac{mk \sin \theta}{d^2 + r^2}$, a finite value, and also the maximum value it can have.

Making

$$\begin{aligned} \varphi &= 180^\circ \\ \theta &= 0 \\ \sin \varphi &= 0 \\ \cos \varphi &= 1 \\ \sin \theta &= 0 \end{aligned}$$

and substituting the expression, again reduces to zero, showing the entire independence of the sun's attraction on the weight of a particle on the surface of the earth at a point directly opposite the sun.

Making

$$\begin{aligned} \varphi &= 270^\circ \\ \theta &= \text{sun's horizontal parallax} \\ \sin \varphi &= -1 \\ \cos \varphi &= 0 \end{aligned}$$

$\sin \theta$ is finite and positive.

Substituting and reducing we have

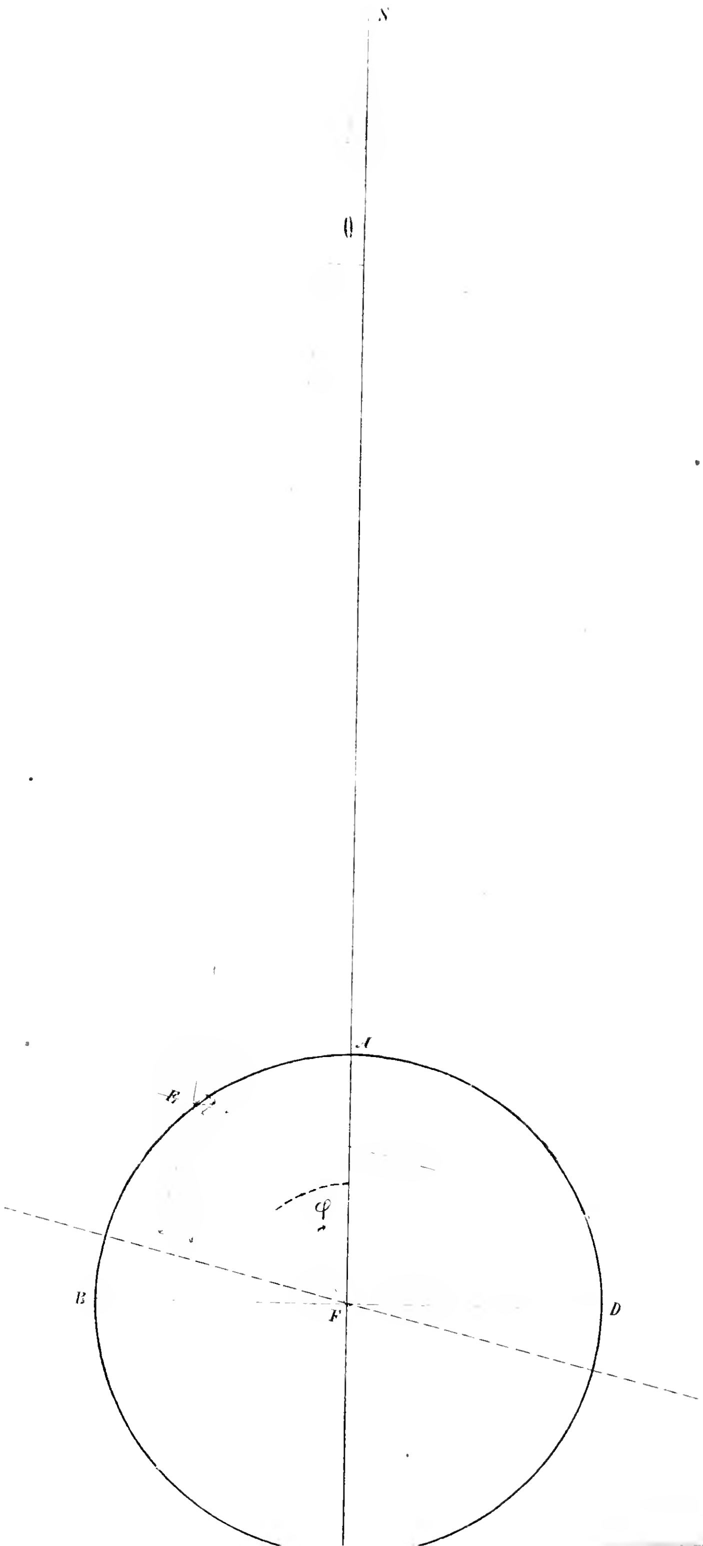
$$-\frac{mk \sin \theta}{d^2 + r^2}$$

the negative sign showing the line of direction has changed, while the intensity is the same as when $\varphi = 90°$, and this must be so in order that the line of direction shall be towards the centre of the earth.

The values of this component being zero at A and C and positive at B and D (the negative sign not affecting the intensity, but simply showing its direction), and being connected by the law of continuity, it follows that the effect of the sun's action upon the unit of mass is to increase its weight from A in both directions to B and D, and to decrease this weight from B and D to C; and as this is true of all sections of the earth by planes through its centre and that of the sun, it follows that waters of the ocean on and near the circumference of a section of the earth by a plane through the earth's centre, and perpendiculars to these, will, by the principles of hydraulics, press up those about A and C until an equilibrium of the pressures due to increased weight and increased height is established, thereby producing the solar tidal wave.

The same course of reasoning is applicable to the moon's action, showing that the weights of bodies are increased from the point of the surface of the earth immediately adjacent to the moon, until the bodies are at an angular distance of 90° from the moon in all directions, and that then the weights decrease until we arrive at that point of the earth's surface immediately opposite the moon.

I think nothing further need be said to show the fallacy of the so-called "experimental proof" referred to in the paragraph quoted from the *Popular Science Monthly* in regard to the weight of a body at midnight. I do not wish to be understood as asserting that a body could not weigh heavier at the civil midnight, for the relative positions of the sun and moon can be such as to produce this effect; but if we suppose a hypothetical body that would produce the combined effect of the sun and moon and call its upper transit tidal midday, and its lower tidal midnight, a body would weigh the least at those times and the most at tidal six o'clock morning and evening.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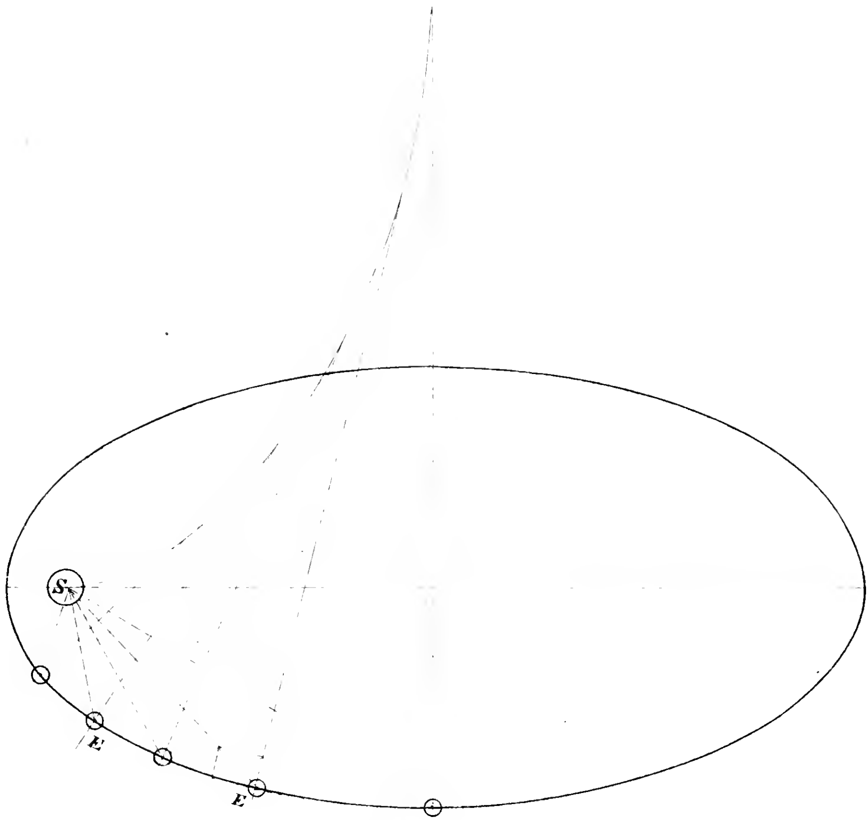

I FRIEDENWALD LITH·BALTO.

NAVAL INSTITUTE, ANNAPOLIS, MD.

NOVEMBER 2, 1882.

COMMANDER N. H. FARQUHAR, U. S. N., in the Chair.

DISCUSSION: PRIZE ESSAY, 1882.

OUR MERCHANT MARINE: THE CAUSES OF ITS DECLINE, AND THE MEANS TO BE TAKEN FOR ITS REVIVAL.

The following letter from Captain A. P. Cooke, U. S. N., was read by the Secretary:

The subject of the essay before us is one of vital importance to our country, and of especial interest to the Navy. The able discussion of it here presented reflects great credit upon the successful essayist, upon the Institute of which he is a member, and upon the service to which he belongs. He has clearly demonstrated that our shipping interests have derived no appreciable benefit from the wonderful expansion of our foreign commerce; that we have furnished the cargoes and paid all the costs of transportation, while others have supplied the ships and sailors and reaped all the benefits: gathering on the sea the golden results of our growth and prosperity on the land. The revival of our merchant marine is a vital issue, not only because it is intimately connected with our financial prosperity, but because of its bearing on the national defense. It has never been the policy of our country to maintain a large navy, and therefore the necessity is greater for us to support an efficient marine, where sailors and ships can be found, ready to fight their country's battles in time of war, and busy in accumulating its wealth in time of peace. It is the cradle of our navy, the nursery for our seamen who are to man our ships of war.

The development of the modern ocean steamship, with its great speed and capacity, has given a new turn to naval affairs. It has exposed a coast nation, like our own, to new perils, and made the state of its merchant shipping of the utmost importance to the national security. We can never be seriously menaced except from the sea, and the immense distances of our sea-coast peculiarly expose us to danger from the attacks of a naval power. In all probability our future wars will be on the sea, and we are now furnishing the principal means of support for legions of foreign sailors, upon whom our enemies must rely to humiliate, if not to crush, us in the event of a war.

Sailors cannot be trained in a day or a year, or in sufficient numbers for the defense of a great nation without the assistance of an efficient merchant marine. Something must be done then, unless we are prepared to abandon forever our natural and proper share of the carrying trade of this country and of the world to our rivals. The American sailor must disappear, and the power even to defend our own coasts be given up, unless in some way we regain a fair share of that trade. No interest is so peculiarly and emphatically a national one. Our coasts and harbors must be defended in case of war; this cannot be effectually done without a navy, and we cannot successfully maintain a navy without a merchant marine. Even now the government finds difficulty in efficiently manning the few ships it keeps afloat. The national weakness which results from the decline of our marine is a source of alarm and regret. All the reasons for maintaining a navy are involved in the necessity for reviving our merchant marine; they must go hand in hand, and their development must be mutual. With the decline of our marine we have lost position as a naval power, and seem to have no settled policy with regard to either of these great interests.

Our laws present many obstacles to the development of our marine which are easily capable of removal, and we must in a great measure look to our national legislators for its revival. This can be accomplished only by appropriate legislation, which shall carefully and completely revise and remodel the laws relating to sailors and the merchant marine, so as to favor the shipping interests and more fully recognize the rights and privileges of our vessel owners; relieving those engaged in foreign trade from all restrictions and burdens which place them at a disadvantage in competing with foreigners. Our rivals have already monopolized the carrying trade, and unless we can offer some encouragement that will be substantial and assuring, it will indeed be a difficult matter to restore it to our own people. When we look abroad and see their eager preparation to transport cheaply our products, we can begin to realize the great opposition we shall have to encounter. They will certainly make every exertion and sacrifice to keep down our attempted competition, and they have the advantages of low wages and low interest, of occupying the field, and of having a numerous body of well-trained artisans and immense organized capital at their disposal. As the decrease of our shipping has been gradual, so must be its restoration; it is more difficult to build up a trade after it has passed into other hands than it is to lose it by indifference and neglect. While we have been retrograding in this particular, others have been advancing, and our progress under the wisest and most efficient legislation and assistance must be slow and laborious.

In the palmy days of our merchant marine it challenged the competition of the world, and maintained its large share of foreign trade by unwearied exertion, tact and intelligence, and by admirable and economical management. Let us hope that these causes will again enable American ships to keep their element and show the flag of their country in distant seas, whenever we are able to compete on favorable terms with our rivals. It is now a humiliating reflection that the inhabitants of the world at large have so little to remind

them of the existence and resources of the United States. One sees the flags of other nations, even to the third and fourth rates, everywhere afloat, in the harbors and on the high seas, while the exceptional appearance of our own excites curiosity and comment.

THE CHAIRMAN.—That the Naval Institute should have selected this topic for a Prize Essay is not to be wondered at.

The whole country is startled by the fact that our ocean carrying trade is rapidly leaving us. A quarter of a century ago England was our only competitor; but to-day, while our country is most prosperous, the imports and exports being greater than ever before, our ships are so few that some people doubt whether we have any. $100,000,000 are earned annually in freights to and from our country: why should we not have the largest share of this sum?

The prize essay very clearly gives many reasons for this decline; the principal ones being our bad navigation laws and the high tariff. That these have had their effect cannot be doubted, but I think the late war and the change from sailing to steam vessels are very important factors. The war served to divert capital from this industry to others which seemed to be better investments; and the adoption of steamers required a much larger outlay.

We naturally invest our money where it will yield the greatest return. Vanderbilt, who owned the only American line, sold out and invested his money elsewhere, because he could get larger returns, and in a few years made an immense fortune.

The Collins steamers were the finest in the world, but they were too luxurious for their day, too costly, and not economically managed; and through this and their bad luck in losing some steamers, and the non-continuance of their subsidy by Congress, they became bankrupt.

The merchant service should be a nursery for the navy, so that we would have, in case of war, a source of supply of officers and men for both. Those of us who were in the late war know that if we had not had the merchant service furnishing volunteer officers and men, the result might have been different. This is now, as then, most important.

There are several means given in the essay for revival—subsidies, free trade, new navigation laws, and new shipping laws, as well as the repeal or reduction of certain taxes or charges. Whatever means are adopted they amount to a subsidy. If we have free trade, the revenue of the country is diminished, and the same may be said if the various charges and taxes are repealed. Would it be best to grant a subsidy, to repeal existing laws, or to make new ones?

We must look at this, not in the interest of individuals, but in that of the country at large. Perhaps one reason why subsidies have not succeeded is that they were not granted for a term of years, but had to be renewed annually, so that the cost to the company for the importunity of renewal amounted to nearly as much as the subsidy itself.

It is thought by many that a large navy is not necessary to maintain an extensive merchant marine, and Norway is instanced as a proof. But can any

one doubt that if men-of-war were generally withdrawn from the ocean that the seas would not once more become infested with pirates? Pirates, being common enemies, are put down by any nation, so that those nations which have few or no men-of-war are taken care of by those that have many. A good thing as long as it lasts, but very disastrous if all practised the same short-sighted economy.

As naval officers, we should keep the subject of the revival of the merchant marine before the public, for its revival will benefit the Navy; and while we may not agree with the Prize Essayist as to the manner of revival, still the continued agitation must, in the end, produce the desired result.

THE REVIVAL OF THE AMERICAN CARRYING TRADE.

AN ANSWER TO THE QUESTIONS OF THE JOINT COMMITTEE OF CONGRESS, APPOINTED TO INQUIRE INTO THE CONDITION AND WANTS OF AMERICAN SHIPBUILDING AND SHIPOWNING INTERESTS.

By John Codman.

Mr. Chairman and Gentlemen:

Although I have not seen the text of the joint resolution authorizing the appointment of your committee, it is gratifying to be able to infer from the circular I have the honor to receive from you, that you have been delegated to consider two separate and distinct questions which Congress has heretofore regarded as united. Shipbuilding is one industry, shipowning is another. It is desirable that our country should have both; but if we cannot have the former, you will admit that it is folly to deprive ourselves of the latter.

Your first question is:

Why cannot this country build iron, steel, or wooden vessels as well and as cheaply as they are built in Scotland, England or other countries?

Answer. We can and do build wooden vessels as well and as cheaply as vessels of good quality are built elsewhere, and cheaper than they can be built in Great Britain. It was for this very reason, in days before the era of extensive iron shipbuilding, that England repealed her navigation laws, which were then similar to our own, in order that her people might still have their share of the carrying trade even if they could not compete in shipbuilding; an example that now, when circumstances are reversed, we would do well to imitate. In wooden shipbuilding the proportion of cost in material as compared with labor is far greater than in iron shipbuilding. The cost of plant is infinitely less, and the cheapness of the wood compensates for the difference of labor. Finally, this part of the question may be set at rest by considering the small demand there is now for wooden ships for the great purposes of ocean commerce.

We cannot build iron and steel vessels as well as they are built elsewhere, partly because competition is wanting. We need abundant foreign as well as the extremely limited home competition that we have, in order to arouse the talent and energy of our own shipbuilders.

We cannot build ships as cheaply for reasons that the shipbuilders themselves assign. Mr. Roach has repeatedly stated that 90 per cent. of the cost of an iron steamship is labor, and he has printed a table in one of his pamphlets going to show that the cost of labor in this country is double the cost of labor in Scotland. The following schedule, intended as an argument for protection, from a recent number of *Our Continent*, purports to corroborate his statement in the latter respect. If both assumptions are strictly true, your question is abundantly answered.

"COST OF SHIPBUILDING IN ENGLAND AND AMERICA.

"In a shipyard, to build an iron ship, thirty-six classes of mechanics are employed, and these handle the raw material after it is made into shape. Let them be divided, for brevity's sake, into five departments, viz. Shipyard department, with fourteen different grades of employment; steam engine department, numbering seven grades; boiler department, seven; iron and brass foundry department, four grades each. In the first department the highest wages paid go to the shipsmith, and the lowest to the rivet boys. In the United States the shipsmith receives, per week, $15.95; in England, $6.05; the rivet boy here gets $3.30, and abroad, $1.69. In the steam engine department the draughtsman with us receives $19.80; in England he has $8.22. A helper in this department in this country gets $8.80; in England and in Scotland, $3.87. In the boiler department in the United States a flange-turner gets $16.50; the same man abroad gets $6.20. A loam moulder in the iron foundry here gets $16.50; in England, $6.50. Brass moulders with us receive $14.30 and in England $6.15. The total week's wages of thirty-six men in England would be $192.60, while in the United States their wages would be $406.01. In a shipyard, in good times, both here and in England, which might employ 2000 men, they would receive in that case with us $22,540, and in England or on the Clyde only $10,700."

Of the cost of a $500,000 steamship, according to Mr. Roach's éstimate, $450,000 would be for labor in England. The same labor here would cost $900,000! A manifest absurdity, and yet a logical deduction. Both statements are greatly exaggerated, while there is truth enough in them to meet your question. I once examined the books of Messrs. Denny and Co., the builders of the "Parthia," Cunard s. steamship of 3000 tons, at Dumbarton, Scotland. Her cost was about £100,000 ($500,000).

There was 162,500 days' work done upon her, in which I do not include the manufacture of the iron from the pig, nor the making of the sailcloth, ropes, &c., but given the plates, angle iron, canvas, cordage and all other materials as they come from the makers' hands ready to go into the composition of the ship.

At that time there was about a dollar in gold difference per day between the average Scotch and the average American wages. Both have since increased, but the ratio of difference holds good. Of course on account of our tariff the iron as well as all other materials, excepting the wood used, costs considerably more here than in Scotland. But that is a matter of comparatively small account. There was only about 1750 tons' weight of iron in that ship, and a few dollars' difference in its cost is a mere bagatelle when merged in $500,000.

Not considering it at all then, the cost of such a ship if built here would be $162,500 more than if built in Scotland, besides which if the difference in cost of the iron *ab initio* before it was wrought into plates, boiler iron and angle iron should be taken into account, it would amount to a great deal more. But putting the lowest estimate of difference, these figures show that it is more than 30 per cent. Yet in the face of his own superabundant calculations, and these more moderate ones, Mr. Roach has frequently stated that the difference in the whole cost of building a ship is only ten per cent.!

The only reply that has been made to this damaging summing up is that all the difference in the cost of shipbuilding, excepting about 10 per cent., is overcome by the superiority of American workmanship, the advantages of American iron, and improvements in American machinery. As to the first, it is well to bear in mind that it comes from a gentleman of Irish birth and raising, and that nearly all his employés are Irishmen or Scotchmen, many of them imported from the shipyards of Great Britain. As for the superiority of American machinery, it is well to remember that in Great Britain there is neither a tariff on American iron nor on American ideas. If our iron would serve their purpose better than their own, the astute Scotsmen would surely import it, and where, in consequence of the competition among themselves, every labor-saving invention is eagerly adopted, we may be sure that no false national pride would prevent its introduction, even if it came from the Delaware.

One curious inconsistency is seen in the complaints of our shipbuilders, who assert that there is only 10 per cent. against them, and at the same time deprecate the importation of free ships, the effect of which, as they say, very possibly with truth, would be to advance the price in Scotland 20 per cent. If they are correct in both premises, manifestly the American shipbuilder would have an advantage over the Scotsman of 10 per cent., and again neither British law nor British pride would prevent Englishmen from supplying their necessities in the cheapest market, as they now do when they require wooden ships.

SECOND. *If we had such vessels without cost to us, could they be run by us in competition with those of other countries who build their own vessels and run them with their own officers and crews, without a modification or repeal of existing laws?*

ANSWER. I have to presume that this question is seriously put. When wooden sailing ships were the carriers of the world, I have already shown that England so feared our competition that she repealed her restrictive navigation laws. We competed with her then in sailing ships under the same domestic disabilities that we now bear. I am not aware that our tonnage dues, which are the same as those levied on foreign vessels, were less then than now. We

were obliged to pay duties on our stores and ship-chandlery under various tariffs, all of them bad enough, though perhaps not quite so outrageous as the present imposition. We paid our captains and officers higher wages than other nations paid theirs, and we fed our ships' companies better. As to sailors, to the shame of a nation that engaged in a civil war for the freedom of Southern negroes, they are white slaves, everywhere bought of landlords in our seaports, who sell these chattels for the highest prices they can get to American and foreign vessels alike. So there is no difference there. As to taxation, in some States, notably New York and Massachusetts, we are better off now than we have ever been, for these States have passed laws exempting their shipping from taxation as personal property. In England it is not taxed as personal property, but its profits come under the income tax, which does not exist with us.

Our consular system is disgraceful. It always has been disgraceful, but it is no more so now than it ever was. It cannot be otherwise without an application of civil service reform, with continuance in office dependent on fitness and merit, and the payment of consular salaries out of the national treasury instead of out of the pockets of shipowners. As to port dues and pilotage, embraced in the succeeding question, but forming also a part of the answer to this, they are no more than foreigners pay.

Lastly, in the days of wooden sailing ships, when we competed so advantageously with England, nobody proposed to *give* us ships. Like Englishmen, we were obliged to buy them. Therein is precisely the advantage that all foreigners have of us now. They can buy ships anywhere with their own money; we cannot. The ships would certainly be handsome presents if a generous government would give them to us. The interest, 6 per cent., and insurance, 7 per cent., on a steamship valued at $500,000 would amount to a saving of $65,000 annually, a sum large enough to pay all her port charges, pilotage, &c., at home, and leave a considerable residue for the benefit of our consuls abroad. But as this liberal offer is not likely to be made, we will be contented to pay our own bills.

Still, it would be desirable to have these petty charges modified. I have only intended to show that they are not the main impediments to our success.

I have demonstrated that we should be the gainers of $65,000 annually on every $500,000 ship which some fairy may be supposed to give us. Let us see how much we should save if we acquired the ship in England without supernatural aid.

Such a ship would cost here $650,000. The yearly interest and insurance on the excess of $150,000 is 13 per cent. The wear and tear and depreciation on an iron steamship is yearly at least 7 per cent. Therefore it would be 7 per cent. on this excess, making in all 20 per cent. on the $150,000, which would be $30,000.

Now, that amount, although less than half of the $65,000 we should gain in your supposed case, is still much more than enough in this real case to cover all the extra charges to which we are subjected, and of which so much complaint is made.

THIRD. *What modifications of existing laws or what new laws are required to remove discriminations against and burdens upon our shipping and shipowning interests, such as customs dues, port dues, consular charges, pilotage, tonnage, and other dues, &c.?*

ANSWER. I have already considered a part of this question. Please read sections 4131, 4132, 4133, 4134, 4135, 4142, 4143, 4163, 4165, 4172, of our navigation laws, and tell us if in the maritime code of any other nation anything can be found more barbarous and stultifying. What better can be done than to repeal them?

FOURTH. *Compare the laws of other countries with our own with a view to their effect upon our and their shipping and shipowning interests.*

ANSWER. To institute a minute comparison would be tedious and superfluous. In general, the laws of other countries give freedom to the carrying trade. Ours bind it in chains.

FIFTH. *Should our navigation laws be repealed or modified, and if modified, wherein and for what purpose?*

ANSWER. Yes, for the good of the whole country they should be absolutely repealed; but if shipbuilding for the coasting trade is still to be protected at the cost of the community, they should be merely so modified as to leave that virtually intact.

SIXTH. *What is the cost of the component materials of iron, steel or wooden vessels in other countries and our own?*

ANSWER. In general, the freight and duties added to their cost abroad will, with a small percentage of profit, indicate their price in this country.

SEVENTH. *What would be the effect of a rebate on any or all such materials?*

ANSWER. It would, if ships were imported free, give the domestic shipbuilder an opportunity to compete if he could; but there is no more reason why there should be a rebate on parts of a ship than on a ship herself. Let both be made free.

EIGHTH. *Present any other statements connected with the cause of the decline of the American foreign carrying trade and what remedies can be applied by legislation.*

ANSWER. The sole reason for the decline of our carrying trade is the neglect of our government to pursue the same liberal policy that other nations have adopted. No farmer can cultivate his ground as cheaply as his neighbor, unless he can have his implements of husbandry on as favorable terms. Let him make them if he can. If he cannot do so economically he must buy them, or his farm will not be a success.

Of all propositions for the restoration of our general carrying trade, the subsidy scheme would be the most ineffectual. It never has been adopted by any other nation for that purpose. It must be apparent to any unprejudiced mind that while subsidies may be needed for mail service, and for mail service only, the subsidized lines tend to prevent the business of private merchantmen by their ability to run them off. Subsidies are, therefore, for individual benefit, and necessarily opposed to the benefit of the public.

The means I would propose for the desired object are the same that I sug-

gested to the Congressional Committee appointed in 1869, and have steadily adhered to from that time. They are as follows:

1st. The admission to American register of all vessels of over 3000 tons.

2d. The admission of all materials to be used in the construction and repairs of vessels of over 3000 tons, duty free.

3d. Exemption from taxation, local and national, on all vessels engaged in the foreign trade.

4th. Permission for all American vessels in the foreign trade to take their stores and ship-chandlery out of bond duty free.

5th. A general revision of our laws relating to seamen, and also of those regulating consular service, so that the charges which now weigh in any degree on American shipping at home and in foreign ports may be diminished, and made to accord as far as possible with those imposed under the English system.

I have suggested a limited tonnage which will not materially interfere with the coasting trade, rather than the admission of ships to be used in the foreign trade exclusively.

The reason is that no Americans would wish to own ships whose voyages they could not control. If they could not use them when they desired to do so in the coasting trade, they would prefer to own them as they own them now under the British flag, because it is more economical, and they are protected by a more efficient navy than ours.

In conclusion, I am sorry to express the opinion that, do what Congress will in the way of removing our burdens, even to the extent of granting absolute freedom and copying our navigation laws in all respects after those of England, measures that would have been eminently successful in the outset, the restoration of our carrying trade will be a labor of years. We have lost our prestige and experience; we are no longer a maritime nation; our shipowners have been wearied and disgusted; they have gone into other business, forced by their government to abandon their old calling. And the way back under the most hopeful conditions must be uphill and slow. Our shipmasters, the pride of the ocean in the old packet days, are dead, and they have no successors. Congress, by its supine neglect, has all this for which to answer. While it has lent a listening ear to bounty and subsidy seekers intent only on personal gain, its committees have never been willing to report a free ship bill, nor has the Senate, or the House, allowed the subject to be otherwise than incidentally debated.

These, gentlemen, are sober truths, and I appeal to you now to rectify the errors of the past so far as it is in your power.

NAVAL INSTITUTE, BOSTON BRANCH.

MAY 31, 1882.

LIEUTENANT-COMMANDER A. S. SNOW, U. S. N., in the Chair.

DISCUSSION:

RIGGING AND EQUIPMENT OF VESSELS OF WAR.

CAPTAIN R. CHANDLER.—In the few remarks I am about to make, Mr. Chairman, I will confine myself to the subject of rigging our proposed new cruisers, and will commence with

TELESCOPIC MASTS.

The great advantage of this style of masts seems to me to be the rapidity with which the wind-resisting surface can be reduced when it becomes necessary to steam against adverse winds. Another important consideration is the lowering the centre of gravity.

The sending down of the light yards and masts is but a few minutes' work; and in this connection I would suggest a change in the present mode of stowing these light spars when down. As a rule, they are triced up to the bulwarks or stowed amidships, invariably in the way, and so placed as to render the sails liable to become wet and dirty in bad weather or when washing down the decks. I would recommend that a place under cover be assigned for these light spars, in order that this difficulty may be overcome. When the light yards and masts are down, it is only necessary to remove the topmast fids and send down the topmasts inside of the lower masts, thus reducing nearly one-half the wind-resisting surface.

It was a common practice in the old Collins line of steamers, when the American flag was upon the ocean, to send down the lower and upper yards and land them in cranes when steaming head to wind, the jeer falls and yard ropes being always kept rove, thus reducing the wind-resisting surface and lowering the centre of gravity. We certainly have ingenuity enough in the Navy, when it is necessary to steam head to wind, to send down the spars rapidly, and as quickly restore them to position. By fitting the proper mechanical arrangements to that portion of the proposed masts between decks and to the mastheads, they may be made to serve the admirable purpose of ventilators, introducing fresh and allowing the escape of foul air.

HOISTING ENGINES.

Small engines near the heel of the fore and main masts, with leading holes for purchases through the decks, would be the means of saving labor in many ways. They might be used in sending up masts and yards, getting in and out boats and howitzers, coaling ship, and for other purposes that will readily suggest themselves to the minds of the gentlemen present. These small engines, entirely out of the way and requiring but little space, would facilitate work and save time that could be more advantageously used for purposes of instruction and drill; in fact, they would add fifty per cent. to the working force of our ships, necessarily rendering them more efficient.

Any man can haul on a rope, but only a few can pass a weather earing, point a gun with accuracy, or handle a boat in a heavy sea. The use of labor-saving machines on board a vessel of war does not necessitate idleness, for any intelligent man in command of an American man-of-war, supported by such officers as our Navy possesses, can always find employment for those under his command, in the line of professional advancement.

In the tropics the use of hoisting engines would be the means of preventing much sickness, the usual result of exposing our men to the intense heat of the sun when it becomes necessary for them to do the heavy work I have just mentioned. The argument that if steam is used for labor-saving purposes the crew will be brought up in idleness, is both narrow-minded and unprogressive, and, in my opinion, reflects upon the intelligence of those opposed to labor-saving appliances. Nothing yet has ever been invented to save labor that did not directly or indirectly benefit the laborer.

DOUBLE TOPSAIL YARDS.

I am an advocate of these yards for all our cruising vessels, as they are labor-saving, which is an important item when we consider the limited complements of our naval vessels in time of peace, and they can be recommended for general handiness. If double topsail yards should be adopted with telescopic masts, the close reefed or lower topsail may be carried with the topmast housed, as the lower topsail yard trusses to the lower cap, rendering it independent of the topmast.

SPARE SPARS.

Not many years ago our ships were supplied with almost a complete set of spare masts and yards. Gradually the number has been reduced, but I think the reduction can be carried still further. As spare spars are now stowed, they are *splinter makers* in time of action, instead of *shot arresters*, as formerly was the case when twelve and eighteen pounders came under the head of heavy ordnance.

In the present days of steam no ship is ever placed in such a position that she cannot readily make port, when it becomes necessary to replace spars that have been carried away. If the yards and masts for the fore and main should be supplied of the same size, a reduction of the number of spare spars to be carried would necessarily follow.

FITTING OUT.

Having had considerable experience in our dockyards, it has occurred to me that it would be most advantageous to have the steam engineering department so far ahead of the others that steam could be used from the commencement of the masting, so that most of the heavy work could be done by the steam capstan. In fact, if only one donkey engine could be made available, much labor would be saved.

With the powerful steam capstan in use, a ship could be masted, sparred, rigging set up, guns and stores taken aboard, and, in the event of its becoming necessary to move from wharf to wharf, the capstan could be used for warping. The laborers and bull teams, usually required for this work, could be employed for other purposes.

BLOCKS AND ROPES.

I will devote the remainder of my remarks to easy running gear, and an improvement upon the methods now in use.

All the blocks not requiring to bear a heavy strain should have patent or friction rollers. Much more attention ought to be paid to the lead of the running rigging. It is said that pennants on braces are unsightly, but they are labor-saving and could be fitted with advantage. Every deck officer in the service knows that it is frequently necessary to put a whole watch on a weather reef tackle, as at present fitted, in order to haul it out, while in a merchantman one-fifth of the same number of men would be sufficient to do the work.

Let any seaman go to the maintop of one of our vessels in commission and see for himself the labyrinth of ropes sawing together through the lubber's-hole, and he will not wonder that it takes a green hand six months simply to *learn the ropes*. I maintain that in our new ships the lead of every necessary rope ought to be carefully marked out and provided for.

I commanded one ship where the main brace led through six different sheaves and dumb sheaves before it reached the hands of the men, and it was with difficulty the entire watch braced the yard. When the main braces were rove "merchant-ship fashion," seven men could easily do the work formerly required from a whole watch.

My remarks upon the subject of this discussion have, from pressure of other duties, necessarily been prepared hastily, and are expressed with the rough directness of haste, but they represent matured consideration and a fair amount of experience. I have never been able to see any good reason why the U. S. Navy, with competent officers, able and willing seamen, should always be behind its own merchant service, and that of every other civilized country, in labor and time-saving appliances for the proper handling of a ship at sea.

LIEUTENANT F. S. BASSETT.—Many improvements have been made in rigging and equipping our naval vessels within the past twenty years. Wire rigging has come into general use. Spare spars have been partially discarded. Patent trusses and slings give greater command of the lower yards. Any one who has tried the strength of a whole watch, however, in bracing sharp up, will

be glad to see these trusses with a movable band about the mast, as in the Hartford. This is certain to facilitate the work of bracing, whatever objections against them may appear. The slings of the yards bolt to the trestle-trees in the Hartford, with a backing over the cap—another manifest improvement. I see no reasons why these should not be made of wire rope instead of chain. At any rate, preventer slings of wire might be furnished, instead of the present bulky hempen ones.

We now carry one year's stores, instead of the three years' allowance given to our ancestors, gaining in room and saving expense.

The Board that drew up the last allowance book accomplished many excellent reforms, and their work is beyond criticism in most respects. It is not probable that they had in consideration at all the principal change hereinafter urged; or, if they did, we may not blame the spirit of conservatism that resisted any sudden changes.

The principal change here advocated in the equipment of our ships is one not altogether new, but untried in our service. This is the substitution of wire for chain cables. I fully believe that the advantages of the former over the latter will be as great as those proceeding from the substitution of chains for hempen hawsers. Such cables should be of galvanized steel wire, cable laid, and they can be made at the rope-walk in the Boston Navy Yard. Homogeneous steel should be used, as more trustworthy and lighter than iron, with the same strength. The wires should be as large as possible, with due regard to pliability, in order to decrease the danger of stranding or breaking. Experience in the manufacture would soon determine satisfactorily these points.

This is not a new idea at all. Wire cables are used to some extent in the English Navy, but I have heard no reports of their performance. If these cables possess the advantages here claimed, they should at least be given a trial.

The first element in their favor is a great reduction of weight. In order to represent this, let us take the Hartford as a medium case, and find what is our gain.

We have for the four heavy chains, each 120 fathoms, weighing each 25,680 lbs.		102,720 lbs.
480 fathoms 5½″ steel wire, at 31 lbs. per fathom, .	14,880 lbs.	
Reduction for cable-laid (20 per cent.)	2,976 lbs.	
Weight wire cable, ...	———	11,904 lbs.
Difference (in favor of wire), ...		90,816 lbs.

Or 45 tons.

This represents one sixty-fourth of the whole displacement weight, and does not include further possible reductions in the weight of gear, fittings, &c. This reduction in the weight of gear is of sufficient importance to be given a trial, as we will find it imperative in our new ships to keep down the weights as much as possible. It is not here proposed to make any change in the stream cables, nor in the cables for boats, although these would be attended by similar

gains in weight, which in the case of the Hartford's stream would amount to some two tons more.

Next, as to strength: In the selection of the 5½″ cable there is an apparent advantage on the side of the chain. The breaking strain of the Hartford's 1⅞″ chain is 225,000 lbs.; the breaking strain of the 5½″ steel wire cable is about 195,000 lbs.—a difference of 30,000 lbs. But this is perhaps deceptive, as it does not consider the safety strain, and the elasticity of the wire and its consequent greater standard strength at normal tensions. We could easily gain this strength of the chain by using 5¾″ rope, but it is believed that 5½″ will be all that is required.

The element of cost is important. The chains of the Hartford are invoiced at $5136 each, or a total of $20,544. The steel wire cable would cost, at the present time, 25 cents per pound, or in all, $11.904 \times 25 = \$2976$, a gain in favor of the wire of $17,568 in a single ship.

There are further considerations. Convenience of storage is in favor of wire, and here again is an attendant reduction of weights. We might clear from the hold the huge and clumsy chain-tiers, and substitute therefor a strong but light iron or steel reel, suspended from the beams above or to uprights, and revolved, perhaps, by steam.

Convenience in handling is another advantage claimed for the wire cables. It would be necessary to make no material changes in the capstan, which might be simplified; the iron castings about the base of the patent capstan, and the rollers in the deck; thereby again saving weight. The cable can be hove in just as was the old hempen one, or by winding it directly about the capstan, as in ordinary hoisting. The wire cable would be more easily bitted, and as readily controlled, although some improvement in the matter of controllers or compressors may be necessary. The deck-stoppers would require no alteration, as the lanyards would nip as readily as in the case of a hemp cable.

There is another important consideration in the proposed change: The wire cable would bring in less mud, would therefore retard less the operation of heaving in, and we would be rid also of the frequent inspection of pins and stays and its attendant dirt and noise.

On account of the reduction in weight, the greater pliability and flexibility of the cable, fewer men would be required to handle it; it would be far better adapted for use in carrying out an anchor, and, finally, there would be less noise in its use.

Further advantages would result from the use of the smaller wire cable, viz. smaller hawse-holes, drier decks, and less danger in an open roadstead. It may be objected that it will be difficult to clear hawse, that the cable, on account of less weight, will be too much "up and down" to allow the anchor to bite well, and that it will foul more than the chain cable. It may be necessary to interpose shackles and swivels at certain points—say 30 fathoms—in the wire cable, for the purpose of aiding in clearing hawse, or we may, with the aid of steam, return to the ways of our ancestors and "tend ship," to avoid a foul hawse, or steam around the anchor to clear it. A greater scope of cable than is now used would probably give enough sag to it to induce the anchor to

bite, and, at any rate, we have steam to assist in holding in gales, and, consequently, are less liable to see the anchor come home. I do not believe that there will be as much fouling as with the chain, on account of the superior stiffness of the wire.

As to comparative durability, data is wanting to institute comparisons. We know that chain cables deteriorate from rust, from wear in handling, and from the rearrangement of the particles of the iron, but I am not aware that any record has been kept of these cables that will tell us the amount of depreciation in a year or a cruise. In regard to wire, galvanization, now very complete, would protect it from rust under ordinary circumstances, but we have no means of telling how much salt water would affect it. Time and experience alone would give us the necessary elements of comparison.

The advantages claimed here, then, for steel wire cables over the present chain ones are: 1st, less weight; 2d, less cost; 3d, equal strength; 4th, convenience of stowage; 5th, facility of handling; 6th, less dirt; 7th, smaller hawse-holes.

NAVAL INSTITUTE, ANNAPOLIS, MD.

LONGITUDINAL AND HOOP TENSIONS IN A THICK HOLLOW CYLINDER.

By Lieutenant Chas. A. Stone, U. S. N.

Consider a thick hollow cylinder, closed at both ends and pressed from within by a pressure q_0, and from without by a pressure q_1. Let r_0 and R be respectively the internal and external radii, and r the distance of any point in the metal from the axis of the cylinder. Let q, p and s represent the radial pressure, hoop-tension and longitudinal tension. From any longitudinal section through the axis, we have

$$\int_{r_0}^{R} pdr = q_0 r_0 - q_1 R. \tag{1}$$

From a cross-section, we have also

$$\int_{r_0}^{R} srdr = \frac{q_0 r_0^2 - q_1 R^2}{2}. \tag{2}$$

Let $p = f'(r)$; then from (1),

$$f(R) - f(r_0) = q_0 r_0 - q_1 R.$$

$$\therefore\ f(R) = -q_1 R;\ \text{and in general}$$

$$f(r) = -qr;$$

$$\therefore\ p = f'(r) = -q - r\frac{dq}{dr}. \tag{3}$$

Let $s = \frac{\varphi'(r)}{r}$; then from (2) we have

$$\varphi(R) - \varphi(r_0) = \frac{q_0 r_0^2 - q_1 R^2}{2}$$

$$\therefore\ \varphi(R) = -\frac{q_1 R^2}{2},\ \text{and in general}$$

$$\varphi(r) = -\frac{qr^2}{2};$$

$$\therefore\ s = \frac{\varphi'(r)}{r} = -q - \frac{r}{2} \cdot \frac{dq}{dr}. \tag{4}$$

From (3) and (4)

$$p - s = -\frac{r}{2}\frac{dq}{dr} \tag{5}$$

and

$$2s - p = -q. \tag{6}$$

First: let $p = s$, then from (5) $\dfrac{dq}{dr} = 0$, $\therefore -q = m$, m being a constant. From (3) and (4) we have also $p = s = m$. This satisfies equations (1) and (2).

For the second solution let $p = -s$ in (5), then $p = -\dfrac{r}{4}\dfrac{dq}{dr}$; and from (3) and (4) we have

$$2q = -\frac{3r}{2}\frac{dq}{dr}, \qquad \therefore \frac{dq}{q} = -\frac{4}{3}\frac{dr}{r},$$

from which by integration we see that q is of the form $\dfrac{a}{r^{\frac{4}{3}}}$.

Differentiating we have

$$\frac{dq}{dr} = -\frac{4}{3}\frac{a}{r^{\frac{7}{3}}}, \tag{7}$$

whence

$$p = -\frac{r}{4}\frac{dq}{dr} = \frac{a}{3r^{\frac{4}{3}}}. \tag{8}$$

We have also

$$q_0 = \frac{a}{r_0^{\frac{4}{3}}}, \text{ and } q_1 = \frac{a}{R^{\frac{4}{3}}}. \tag{9}$$

Substituting these values in (1), we have

$$\frac{a}{3}\int_{r_0}^{R}\frac{dr}{r^{\frac{4}{3}}} = q_0 r_0 - q_1 R = a\left[\frac{1}{r_0^{\frac{1}{3}}} - \frac{1}{R^{\frac{1}{3}}}\right]. \tag{10}$$

Integrating

$$-a\left[\frac{1}{R^{\frac{1}{3}}} - \frac{1}{r_0^{\frac{1}{3}}}\right] = a\left[\frac{1}{r_0^{\frac{1}{3}}} - \frac{1}{R^{\frac{1}{3}}}\right]$$

which satisfies the equation.

Combining the partial equations, we have

$$p = m + \frac{a}{3r^{\frac{4}{3}}} \tag{11}$$

$$s = m - \frac{a}{3r^{\frac{4}{3}}} \tag{12}$$

$$\text{and } q = -m + \frac{a}{r^{\frac{4}{3}}}; \tag{13}$$

$$\therefore\ 3p - q = 4m, \text{ whence } 3p_0 - q_0 = 3p_1 - q_1, \tag{14}$$

$$\text{and } p + q = \frac{4a}{3r^{\frac{4}{3}}}, \text{ whence } r_0^{\frac{4}{3}}(p_0 + q_0) = R^{\frac{4}{3}}(p_1 + q_1). \tag{15}$$

Eliminating $p_1 = p_0 - \frac{q_0}{3} + \frac{q}{3}$, we have

$$3r_0^{\frac{4}{3}}(p_0 + q_0) = R^{\frac{4}{3}}(3p_0 - q_0 + 4q_1);$$

$$\therefore\ p_0 = \frac{q_0(R^{\frac{4}{3}} + 3r_0^{\frac{4}{3}}) - 4q_1 R^{\frac{4}{3}}}{3(R^{\frac{4}{3}} - r_0^{\frac{4}{3}})}. \tag{16}$$

Substitute f for p_0, and solve for $\frac{R}{r_0}$, and we have

$$q_0\left(3 + \frac{R^{\frac{4}{3}}}{r_0^{\frac{4}{3}}}\right) - 4q_1\frac{R^{\frac{4}{3}}}{r_0^{\frac{4}{3}}} = 3f\left(\frac{R^{\frac{4}{3}}}{r_0^{\frac{4}{3}}} - 1\right)$$

whence

$$\frac{R}{r_0} = \left[\frac{3(q_0 + f)}{3f - q_0 + 4q_1}\right]^{\frac{3}{4}}.$$

If $q_0 = 3f + 4q_1$, $\frac{R}{r_0} = \infty$.

From (12) and (13), we have

$$s + q = \frac{2a}{3r^{\frac{4}{3}}} \qquad \therefore\ r_0^{\frac{4}{3}}(s_0 + q_0) = R^{\frac{4}{3}}(s_1 + q_1) \tag{17}$$

$$\text{and} \qquad 3s + q = 2m \qquad \therefore\ 3s_0 + q_0 = 3s_1 + q_1, \tag{18}$$

$$\text{whence} \quad r_0^{\frac{4}{3}}(s_0 + q_0) = R^{\frac{4}{3}}\left(s_0 + \frac{q_0}{3} + \frac{2q_1}{3}\right),$$

$$\therefore\ s_0 = \frac{q_0(3r_0^{\frac{4}{3}} - R^{\frac{4}{3}}) - 2q_1 R^{\frac{4}{3}}}{3(R^{\frac{4}{3}} - r_0^{\frac{4}{3}})} \tag{19}$$

$$\text{and} \qquad \frac{R}{r_0} = \left[\frac{3(f + q_0)}{3f + q_0 + 2q_1}\right]^{\frac{3}{4}} \quad \text{where } f = s_0.$$

p_0 and s_0 are the values of p and s for $r = r_0$,
and p_1 and s_1 are the values of p and s for $r = R$.

From (17) and (18) we have

$$r^{\frac{4}{3}}(s+q)=r_0^{\frac{4}{3}}(s_0+q_0)$$

and

$$3s+q=3s_0+q_0,$$

$$\therefore \quad r^{\frac{4}{3}}(3s_0-2s+q_0)=r_0^{\frac{4}{3}}(s_0+q_0),$$

or

$$s_0(3r^{\frac{4}{3}}-r_0^{\frac{4}{3}})+q_0(r^{\frac{4}{3}}-r_0^{\frac{4}{3}})=2sr^{\frac{4}{3}},$$

$$\therefore \quad s=\frac{s_0(3r^{\frac{4}{3}}-r_0^{\frac{4}{3}})+q_0(r^{\frac{4}{3}}-r_0^{\frac{4}{3}})}{2r^{\frac{4}{3}}}.$$

Substituting the value of s_0 from (19), and reducing

$$s=\frac{q_0 r_0^{\frac{4}{3}}(3r^{\frac{4}{3}}-R^{\frac{4}{3}})-q_1 R^{\frac{4}{3}}(3r^{\frac{4}{3}}-r_0^{\frac{4}{3}})}{3r^{\frac{4}{3}}(R^{\frac{4}{3}}-r_0^{\frac{4}{3}})} \tag{20}$$

whence

$$\frac{ds}{dr}=\frac{4R^{\frac{4}{3}}r_0^{\frac{4}{3}}(q_0-q_1)}{9(R^{\frac{4}{3}}-r_0^{\frac{4}{3}})r^{\frac{7}{3}}};$$

when $\left.\begin{array}{l} q_0>q_1 \\ \text{and } R>r_0 \end{array}\right\} \frac{ds}{dr}$ is $+$, therefore the longitudinal tension is greatest on the outside.

Let $r=R$ in (20),

$$s_1=\frac{2q_0 r_0^{\frac{4}{3}}-q_1(3R^{\frac{4}{3}}-r_0^{\frac{4}{3}})}{3(R^{\frac{4}{3}}-r_0^{\frac{4}{3}})}. \tag{21}$$

From (14) and (15) we have

$$3p-q=3p_0-q_0,$$

and

$$r^{\frac{4}{3}}(p+q)=r_0^{\frac{4}{3}}(p_0+q_0);$$

whence

$$p=\frac{p_0(3r^{\frac{4}{3}}+r_0^{\frac{4}{3}})-q_0(r^{\frac{4}{3}}-q_0^{\frac{4}{3}})}{4r^{\frac{4}{3}}}. \tag{22}$$

Substituting the value of p_0 from (16), we have, after reduction,

$$p=\frac{q_0 r_0^{\frac{4}{3}}(3r^{\frac{4}{3}}+R^{\frac{4}{3}})-q_1 R^{\frac{4}{3}}(3r^{\frac{4}{3}}+r_0^{\frac{4}{3}})}{3r^{\frac{4}{3}}(R^{\frac{4}{3}}-r_0^{\frac{4}{3}})}. \tag{23}$$

Differentiating

$$\frac{dp}{dr}=\frac{4R^{\frac{4}{3}}r_0^{\frac{4}{3}}(q_1-q_0)}{9(R^{\frac{4}{3}}-r_0^{\frac{4}{3}})r^{\frac{7}{3}}}.$$

$\left.\begin{array}{r}\text{If } q_0 > q_1 \\ \text{and } R > r_0\end{array}\right\} \dfrac{dp}{dr}$ is negative, therefore the greatest hoop-tension is on the inside where $r = r_0$; and its value p_0 is given by equation (16).

To determine m.

From (14) $$\frac{4}{3} m = p - \frac{q}{3} = p_0 - \frac{q_0}{3}.$$

Substituting the value of p_0 from (16), and reducing,

$$m = \frac{q_0 r_0^{\frac{4}{3}} - q_1 R^{\frac{4}{3}}}{R^{\frac{4}{3}} - r_0^{\frac{4}{3}}}. \tag{24}$$

To determine a.

From (11) $$a = 3 r_0^{\frac{4}{3}} (p_0 - m),$$

$$\therefore \quad a = \frac{R^{\frac{4}{3}} r_0^{\frac{4}{3}} (q_0 - q_1)}{R^{\frac{4}{3}} - r_0^{\frac{4}{3}}}. \tag{25}$$

Example:

$$\left.\begin{array}{r} \text{Let } r_0 = 1 \\[2ex] R = 8 \\[2ex] \text{and } q_1 = 0 \end{array}\right\} \text{ and we have } \left\{\begin{array}{l} p_0 = \dfrac{19}{45} q_0 \\[2ex] s_1 = \dfrac{2}{45} q_0 \\[2ex] s_0 = -\dfrac{13}{45} q_0, \end{array}\right.$$

s_0 being a longitudinal compression since it is negative.

If the longitudinal tension were uniform over the area of the cross-section, its value would be $\dfrac{q_0}{63}$.

From equation (20) we see that when $q_1 = 0$, and $3 r^{\frac{4}{3}} = R^{\frac{4}{3}}$, or $r = .439 R$ nearly, that $s = 0$; which shows the position of what might be called the neutral surface, within which there is a longitudinal compression, and without a longitudinal tension. In (19) when $3 r_0^{\frac{4}{3}} < R^{\frac{4}{3}}$, s_0 is negative, showing a longitudinal compression. Making $q_1 = q_0$ in (20), we find the longitudinal tension s is uniform and equal to $-q_0$, as might be expected.

From (20) making $s = 0$, we find

$$r^{\frac{4}{3}} = \frac{R^{\frac{4}{3}} r_0^{\frac{4}{3}} (q_0 - q_1)}{3 (q_0 r_0^{\frac{4}{3}} - q_1 R^{\frac{4}{3}})},$$

as the position of the neutral surface.

From (12) when $s = 0$, $r^{\frac{4}{3}} = \frac{a}{3m}$, which agrees with the above.

The preceding formula (16) giving the value of the maximum hoop-tension differs considerably from that heretofore used in the deduction of which the longitudinal stress was considered zero or constant. The existence also of a neutral surface of longitudinal stress is of great interest in the construction of built-up guns. That a longitudinal contraction may accompany a circumferential expansion, and must do so under certain circumstances, is a familiar result of experience.

In the case of a built-up wire gun the hoop-tension could be calculated by the formula heretofore used, in which the longitudinal stress is ignored, and afterwards the hoop-tension and longitudinal stress of the tube could be calculated by the formulas of this article.

NOTE.—The above is given as a mathematical deduction of a function which will satisfy equations (1) and (2), but it may not be the only one which will satisfy those conditions.

PROFESSIONAL NOTES.

INTERFERENCE PHENOMENA IN A NEW FORM OF REFRACTOMETER.

By Albert A. Michelson (Late Master U. S. N.).

(*From the American Journal of Science.*)

In an experiment undertaken with a view to detecting the relative motion of the earth and the luminiferous ether (*Am. Journal of Science*, No. 128, Vol. XXII), it was necessary to produce interference of two pencils of light which had traversed paths at right angles with each other. This was accomplished as follows: The light from a lamp at a, fig. 1, was separated into two pencils at right angles, bc, bd, by the plane-parallel glass b, and these two pencils were returned to b by the mirrors c and d, whence they coincided along be, where they were viewed by the eye or by a small telescope at e.

It is evident that, so far as the interference is concerned, the apparatus may be replaced by a film of air whose thickness is bc—cd, and whose angle is that formed by the image of d in b with c.

The problem of interference in thin films has been studied by Feussner, but his equations do not appear to give the explanation of the phenomena observed. In particular, in the *Annalen der Physik und Chemie*, No. 12, 1881, on page 558, Feussner draws the conclusion that the interference fringes are straight lines, whereas in the above described apparatus they are in general curves; and there is but one case—that of the central fringe in white light—which is straight.

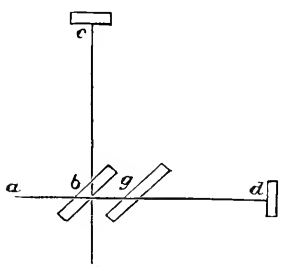

Fig. 1.

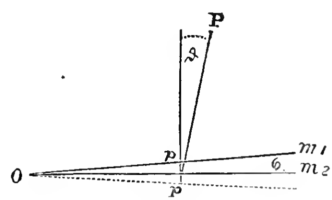

Fig. 2.

I have therefore thought it worth while to attempt the solution of the problem for a film of air, for small angles of incidence and neglecting successive reflec-

tions; and though the solution is not perhaps adapted to the general problem, it accounts for all the phenomena observed in the special case.

Let Om_1, Om_2, fig. 2, be two plane mirrors whose intersection is projected at O, and whose mutual inclination is ϕ. The illumination at any point P (not necessarily in the plane of the figure) will depend on the mean difference of phase of all the pairs of rays starting from the source and reaching P, after reflection from the mirrors; a pair of rays signifying two rays which have originated at the same point of the source.

If the area of the luminous surface is sufficiently large, the illumination at P will be independent of the distance, form, or position of the surface. Suppose, therefore, that the luminous surface coincides with the surface Om_1. Its image in Om_1 will also coincide with Om_1, and its image in Om_2 will be a plane surface symmetrical with Om_1 with respect to the surface Om_2, and for every point, p, of the first image there is a corresponding point, p', of the second, symmetrically placed and in the same phase of vibration. Suppressing, now, the source of light and the mirrors, and replacing them by the two images, the effect on any point, P, is unaltered.

Consider now a pair of points pp'. Let ϑ be the angle formed by the line joining P and p (or p') with the normal to the surface; ϑ and ϕ being both supposed small,

$$\Delta = Pp' - Pp = pp'. \cos\vartheta.$$

The difference between this value of Δ and the true value is $2Pp. \sin^2\frac{\psi}{2}$, where ψ is the angle subtended by pp' at P. If ϑ is a small quantity, ψ is a small quantity of the second order, and $\sin^2\frac{\psi}{2}$ is a small quantity of the fourth order; consequently $2Pp \sin^2\frac{\psi}{2}$ may be neglected. We have, therefore, to a very close approximation, $\Delta = pp' \cos\vartheta$; or, substituting $2t$ for pp', $2t$ being the distance between the images at the point where they are cut by the line Pp,

$$\Delta = 2t \cos\vartheta.$$

Let $cdef$, $c'd'e'f'$, fig. 3, represent the two images, and let their intersection be parallel with cf, and their inclination be 2ϕ. Let P be the point considered; P' the projection of P on the surface $cdef$; and PB the line forming with PP'

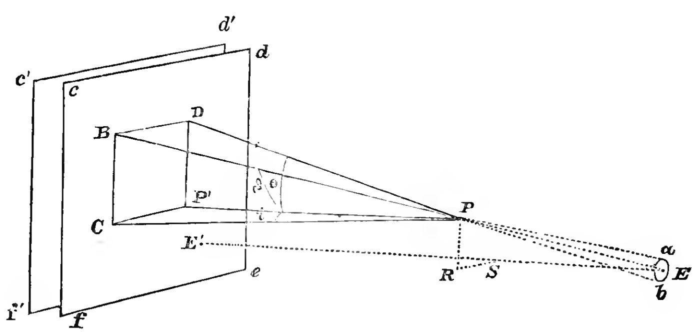

FIG. 3.

the angle ϑ. Draw P′D parallel to cf, and P′C at right angles, and complete the rectangle BDP′C. Let P′PC $= i$ and DPP′ $= \theta$. Let PP′ $=$ P, and the distance between the surfaces at P′ $= 2t_0$. We have then

$$t = t_0 + \mathrm{CP}'.\ \tan\phi = t_0 + \mathrm{P}\tan\phi.\ \tan i, \text{ and}$$

$$\Delta = 2\,(t_0 + \mathrm{P}\tan\phi\tan i)\cos\vartheta, \text{ or}$$

$$\Delta = \frac{2\,(t_0 + \mathrm{P}\tan\phi\tan i)}{\sqrt{1 \quad \tan^2 i + \tan^2\phi}} \tag{1}$$

We see that in general Δ has all possible values, and therefore all phenomena of interference would be obliterated. If, however, we observe the point P through a small aperture, ab, the pupil of the eye for instance, the light which enters the eye from the surfaces will be limited to the small cone whose angle is $b\mathrm{P}a$, and if the aperture be sufficiently small the *differences in* Δ may be reduced to any required degree.

It is proposed to find such a distance P that with a given aperture these differences shall be as small as possible, which is equivalent to finding the distance from the mirrors at which the phenomena of interference are most distinct. The change of Δ for a change in θ, is

$$\frac{\delta\Delta}{\delta\theta} = -\frac{2\,(t_0 + \mathrm{P}\tan\phi\tan i)\,\dfrac{\tan\theta}{\cos^2\theta}}{(1 + \tan^2 i + \tan^2\theta)^{\frac{3}{2}}} \tag{2}$$

The change of Δ for a change in i, is

$$\frac{\delta\Delta}{\delta i} = 2\,\frac{(1 + \tan^2 i + \tan^2\theta)\,\dfrac{\mathrm{P}\tan\phi}{\cos^2 i} - (t_0 + \mathrm{P}\tan\phi\tan i)\,\dfrac{\tan i}{\cos^2 i}}{(1 + \tan^2 i + \tan^2\theta)^{\frac{3}{2}}} \tag{3}$$

For $\dfrac{\delta\Delta}{\delta\theta} = 0$ we have $\theta = 0$ (or $\Delta = 0$).

For $\dfrac{\delta\Delta}{\delta i} = 0$ we have $(1 + \tan^2 i + \tan^2\theta)\ \mathrm{P}\tan\phi = (t_0 + \mathrm{P}\tan\phi\tan i)\tan i$, or

$$(1 + \tan^2\theta)\ \mathrm{P}\tan\phi = t_0\tan i, \text{ whence } \mathrm{P} = \frac{t_0}{\tan\phi}\tan i\cos^2\theta.$$

Hence the fringes will be most distinct when $\theta = 0$ and when

$$\mathrm{P} = \frac{t_0}{\tan\phi}\tan i. \tag{4}$$

This condition coincides nearly with that found by Feussner.

If the thickness of the film is zero, or if the angle of incidence is zero, the fringes are formed at the surface of the mirrors. If the film is of uniform thickness, the fringes appear at infinity. If at the same time $\phi = 0$ and $t_0 = 0$, or $i = 0$ and $\phi = 0$, the position of the fringes is indeterminate. If i has the same sign as ϕ, the fringes appear in front of the mirrors; if i has the opposite sign, the fringes appear behind the mirrors.

To find the form of the curves as viewed by the eye at E, let SE $=$ D; call T the distances between the surfaces at E′, the projection of E. From P draw PR parallel to DP′, and RS at right angles, and let RS $= c$. We have then $t_0 = \mathrm{T} + c\tan\phi$, whence, substituting for c its value D $\tan i$,

$$\Delta = 2\,\frac{\mathrm{T} + (\mathrm{D} + \mathrm{P})\tan\phi\tan i}{\sqrt{1 + \tan^2 i + \tan^2\theta}} \tag{5}$$

If on a plane perpendicular to EE′ at distance D from E, we call x distances parallel to P′C, and y distances parallel to P′D, reckoned from the projection of E on this plane, then, putting $\tan \phi = K$ and $D + P = S$, we have for the equation to the curves, as they would appear on this surface to an eye at E,

$$\Delta = 2 \frac{DT + SKx}{\sqrt{D^2 + x^2 + y^2}} \text{ or}$$

$$\Delta^2 y^2 = (4S^2K^2 - \Delta^2) x^2 + 8TSKDx + (4T^2 - \Delta^2) D^2 \qquad (6)$$

If, numerically,

$\Delta < 2SK$ the curve is a hyperbola,
$\Delta = 2SK$ the curve is a parabola,
$\Delta > 2SK$ the curve is an ellipse,
$K = 0$ the curve is a circle,
$\Delta = 0$ the curve is a straight line.

All the deductions from equations (4) and (6) have been approximately verifie by experiment.

It is to be observed that in the most important case, and that most likely to occur in practice, namely, in the case of the central fringe in white light, we have $\Delta = 0$, and therefore, also, $t_0 = 0$; and in this case the central fringe is a straight line formed on the surface of the mirrors. Practically, however, it is impossible to obtain a perfectly straight line, for the surface of the mirrors is never perfect.

It is to be noticed that the central fringe is black, for one of the pencils has experienced an external, the other an internal reflection from the surface b, fig. 1. This will not, however, be true unless the plate g (which is employed to compensate the effect of the plate b) is of exactly the same thickness as b, and placed parallel with b. When these conditions are not fulfilled, the true result is masked by the effect of "achromatism" investigated by Cornu (*Comptes Rendus*, vol. xciii, November 21st, 1881). This remark leads naturally to the investigation of the effect of a plate of glass with plane parallel surfaces interposed in the path of one of the pencils.

The effect is independent of the position of the glass plate, provided its surface is kept parallel with the corresponding mirror. Suppose, therefore, that it is in contact with the latter, and let cd, fig. 4, represent the common surface. Let $t = hi =$ thickness of the glass, $i =$ angle of incidence, $r =$ angle of refraction, $n =$ index of refraction, $\lambda =$ wave-length of light. Let ef represent the image of the other mirror, and put $n_0 = \frac{hk}{t}$.

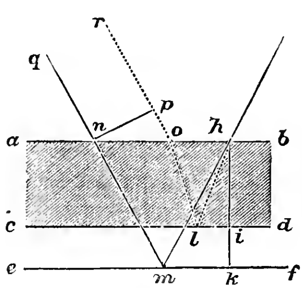

FIG. 4.

It can be readily demonstrated that the path of the rays in the instrument is equivalent to that given in the figure, where one of the rays follows the path $qnmh$, and the other the path $rolh$. Suppose the mirrors cd and ef parallel. Then,

as has previously been shown, the curves of interference are concentric circles, formed at an infinite distance. Therefore, the rays qn, ro, whose path is to be traced, are parallel, and from the point h they coincide. Their difference of path is $2nm—2hl—op$, and their difference of phase is

$$\phi = \frac{2nm}{\lambda} - \frac{2hl}{\frac{\lambda}{n}} - \frac{op}{\lambda} = \frac{2n_0 \cdot t}{\lambda \cos i} - \frac{2t \cdot n}{\lambda \cos r}$$

$$= \frac{2t}{\lambda}(n_0 \tan i - \tan r) \sin i, \text{ whence}$$

$$\phi = \frac{2t}{\lambda}[n_0 \cos i - n \cos r] \tag{7}$$

Let it be proposed to find the value of n_0 which renders any particular ring achromatic. The condition of achromatism, as given by Cornu, is $\frac{d\phi}{d\lambda} = 0$, which gives

$$\phi + 2t\left(\cos r\frac{dn}{d\lambda} - n \sin r \frac{dr}{dn} \cdot \frac{dn}{d\lambda}\right) = 0.$$

We have $$n = \frac{\sin i}{\sin r} \text{ whence } \frac{dr}{dn} = -\frac{\sin^2 r}{\sin i \cos r}, \text{ whence}$$

$$\phi + \frac{2t}{\cos r} \cdot \frac{dn}{d\lambda} = 0$$

By Cauchy's formula we have $n = a_1 + \frac{a_2}{\lambda^2}$, whence $\frac{dn}{d\lambda} = -\frac{2a_2}{\lambda^3}$. Substituting, we have $\phi - \frac{4a_2 t}{\lambda^3 \cos r} = 0$ or $n_0 \cos i - n \cos r = \frac{2a_2}{\lambda^2 \cos r} = \frac{\frac{2a_2}{\lambda^2} + n \cos^2 r}{\cos i \cos r}$,

or, finally, $$n_0 = \frac{2(n - a_1) + n \cos^2 r}{\cos i \cos r}. \tag{8}$$

If the angle i is small, the value of n_0 will vary very little with i, consequently there will be a large number of circles all nearly achromatised. Under favorable circumstances as many as one hundred rings have been counted, using an ordinary lamp as source of light. The difference of path of the two pencils which produce these rings in white light may exceed a thousand wave lengths.

LANDING EXERCISE.

U. S. S. SWATARA, 1882.

(*From Circular No.* 13, *issued by the Bureau of Ordnance.*)

The commander of the Swatara states: "Shortly after my arrival here (Chefoo, China), I called upon the Tao Tai and requested permission to land our battalion under arms for exercise, to continue during four days. This permission was not granted in full, but the Tao Tai granted it for a day or two, with per-

mission to land at any time for daily exercise. Every detail connected with the landing of such a party had been carefully thought out early in the cruise, and a station bill prepared, and, had permission been granted for a stay of four days, I am confident the landing party could have taken provisions and ammunition for the whole time and subsisted independently of the ship. I considered it prudent to keep them supplied with water from the ship."

The party from the Swatara, consisting of 103 officers and men, landed at 4.30 P. M., July 13th, and returned on board at 6 P. M. on the 15th. The detail consisted of a company of enlisted men, 34; a short B. L. H., crew with piece 13; a M. L. 12-pdr. S. B. Howitzer, crew 13, with the field carriage arranged as a provision cart; a squad of marines, 20; a file of pioneers, 4; hospital corps (apothecary and nurse), 2: armorer, 1; markers, 2; bugler, 1; camp cook and assistant, 2; officers' stewards, 2; and 9 officers. As ammunition, twenty (20) rounds were served to each of the men of the infantry command, with one thousand (1000) rounds as a reserve; five (5) rounds of pistol cartridges to each artilleryman, including the crew of the pioneer cart, and twenty (20) rounds of shell for the B. L. H. Each man carried his blanket and a spare suit of blue clothes rolled lengthwise and slung over the left shoulder, his pea-jacket or oil-skin coat in a roll across the shoulders, and a pot, pan and spoon slung to his waist-belt. The mess cook of each company or artillery squad carried one mess kettle and pan. There were carried on the provision cart as follows:

Beef, uncooked	90 pounds.
Pork, uncooked	100 pounds.
Bread	300 pounds.
Sugar	45 pounds.
Coffee	25 pounds.
Pickles	30 pounds.
Beans uncooked	40 pounds.
Dried fruit	20 pounds.
Two boat stoves	180 pounds.
Signal kits (Army and Very)	10 pounds.
Axe, saw, hammer and nails	10 pounds.
Extra ammunition	109 pounds.
Officers' baggage	75 pounds.
Total	1034 pounds.

The point selected for the camp being in a sandy plain three and a half miles in length and about three miles in width at the widest, southern end, with no shelter whatever, or wood with which to construct tent poles, all the materials were supplied by the ship, and were carried on shore by the landing party. They were as follows:

One lower studdingsail for blue-jacket company's tent.

One lower studdingsail for artillery tent.

One topmast studdingsail for marine company's tent.

One topgallant studdingsail for officers' tent.

One topgallant studdingsail for officers' tent.

Two royals for sinks.

All boat sails, one officer's tent and kitchen.

For tent poles, four topgallant studdingsail yards, and all boat spars, pegs and old junk for lashings.

In addition to the above a supply of water for one day was taken, that on shore being judged unfit for use, and also a quantity of firewood for fuel, a further supply of each being landed the following day. With these exceptions, no supplies were furnished by the ships after the party was landed.

The landing and movement to point selected for the camp were conducted as though advancing into an enemy's country, and upon reaching the camping-ground the flankers of the leading detachment were posted as sentinels, and officers of the day and guard were appointed.

Each company first raised its own tent and then that of its officers. The tents were ten in number, and consisted of three company tents, four officers' tents, one kitchen and store-house, and two sinks.

At 8 P. M. the inner line of blue-jacket sentinels was increased to five posts, an outer line of three marine posts established, and a countersign and patrol given. From this time camp routine in an enemy's country was strictly observed. During the night there were frequent visits made to all the posts by the commanding officer of the party, the officers of the day and guard, by rounds from the guard, and by visiting and reconnoitering patrols, both from within and without the lines, and every endeavor made to instruct the sentinels in all their duties.

At 10.45 P. M. exchanged signals, Very's system, with the ships, which were successfully read on both sides.

There was considerable rain the latter part of the night; but, having a good slope to all the tents, the command experienced no inconvenience or discomfort.

After the first night blue-jacket sergeants and corporals were used exclusively, that they might benefit by the experience.

Reveille was beaten at 5 P. M., the outer line of sentinels called in, and roll-call held, after which coffee was served. Breakfast for both officers and men at 6 o'clock.

During the day had target practice with B. L. H. and small arms. At 4.30 formed the camp into an outpost, and it was explained to the men that an attack was expected on the southern side of the camp, from which a high-road was supposed to lead, which branched at some distance from the grand guard, in three directions.

The pickets were marched out and sentinels established, after which a patrol visited all posts and gave detailed instructions for the cases of an advance, the approach of an enemy, a subsequent rally on the pickets, and retreat to the grand guard. These instructions were then illustrated, the command being given by bugle call.

The same system of instructions regarding rounds, visits, &c., was continued during the second night, varying the details with wrong passwords or none at all, to fix the system in the minds of the sentinels.

During the second day had target practice with pistols, with the B. L. H., and with small arms.

In the afternoon the marine company was given sufficient time to conceal itself in a hilly, wooded country, some two or three miles from the camp to the southward, after which the company of blue-jackets was directed to develop their whereabouts, and endeavor to obtain such a position as would lead to their capture, each utilizing the advance guard and outpost instructions given in previous exercise. This occupied the greater part of the afternoon, and furnished to the men many novel and instructive points of actual land service. All parties returned to camp in time for supper at 4 P. M.

At 4.30 P. M. the recall gun was fired from the ship, the camp was broken up at once, and at 6 P. M. all men and material were embarked and on the return. The embarkation was effected in the same manner as the landing. The marines furnished the rear guard, and pickets to protect the operation.

Summary of results.—The sandy nature of the ground, in connection with an occasional stiff breeze and rain, developed no injurious effect either in the B. L. H. or the Hotchkiss magazine rifle. The boat stoves (two, launch size) proved amply sufficient for the needs of the party. As but little previously was known of their capabilities, there was instituted quite a series of experiments to develop them. Boiling, broiling, frying and stewing, in fact every feature in a culinary way, with the exception of baking, was successfully accomplished.

The shelter tents were found to be perhaps one-third too large for the needs of the men.

A SINGULAR CASE OF CORROSION OF STEEL.

By Prof. Chas. E. Munroe, U. S. N. A.

Through the kindness of Chief Engineer Farmer, my attention has recently been called to the appearance of two cold chisels found in the U. S. S. Triana in 1874, and which have since been preserved in the Department of Steam Engineering at the Naval Academy. These chisels were taken from the channelway leading from the jet condenser, and they were located between the foot valve and the air pump. Both chisels were of steel throughout, as was proved by tempering the head. For use, of course, only the points had been tempered. During the time of exposure to the action of the salt water in the channelway the chisels were deeply corroded, but the corrosion was confined entirely to the soft metal, the tempered points not being attacked in the least. The corrosion was deepest at the line of contact between the tempered points and the untempered metal of the haft. The line of immersion, on tempering, is as distinctly marked as if drawn with a shading pen. Since meeting with these chisels I have heard of a similar case of corrosion, although the object has been lost. It was a hammer which had been taken from the boiler of a merchant steamer, the tempered faces of which were intact while the soft metal was corroded.

Remembering the heated discussion going on in metallurgical circles on the question "What is Steel?" I shall not attempt to decide whether the change which takes place in the tempering of steel is a chemical or a physical one, but it is evident that this change produces a body which is not so readily acted upon by salt water as untempered steel is. It is also probable that when the untempered and tempered steels are brought in contact in the presence of salt water we have an electro-chemical couple, and that this hastens the destruction of the untempered metal. I beg to suggest that this observation may have a practical bearing upon the construction of steel ships.

REVIEWS.

An Attempt to Solve the Problem of the Landing Place of Columbus in the New World. Hon. G. V. Fox. Appendix No. 18, U. S. Coast and Geodetic Survey Report, 1880.

The question, what is the island that Columbus named San Salvador, has long been unsettled, and Capt. Fox has contributed another to the numerous answers already given. His choice of Samana, or Atwood Cay, is new and is most ably supported, but although his solution answers many of the necessities of the problem, more so perhaps than any yet proposed, it is open to very strong objections. To assist in a solution the principal authority is the log of Columbus himself, as copied by Las Casas, and this would be all-sufficient, did it not unfortunately contain a few statements which cannot be reconciled with the existing topography of the Bahamas. This difficulty has been recognized by every investigator, and has led to a free interpretation of his statements in advocacy of any solution desired. Capt. Fox has shown praiseworthy industry in his examination of the log, and a conscientious desire to interpret it aright, but is thus led into statements that probably will not be accepted. His thoroughness is shown by the number of authorities, and especially the number of atlases, referred to as throwing light upon the question, but the latter unfortunately differ so much among themselves that almost any view adopted could be supported by some of them. A most valuable feature of the memoir is the verbatim translation of Columbus' log, the credit for which is given to Mr. H. L. Thomas, translator of the State Department.

The keystone of Capt. Fox's solution is the second island Columbus visited. The log describes the trend and length of the shores of this island, and the description agrees very closely with the Crooked Island group, so closely, in fact, as to justify Capt. Fox's statement that "Crooked Island is the only one in the Bahamas that conforms" to it. The acceptance of this, however, for the second island causes great difficulty, as the third island visited lay nine leagues west of the second, and the fourth nine leagues east of the third. If Columbus came back on his own track he would have acknowledged it, but he writes of the fourth island as of something he had not seen, which he was most anxious to reach from the reports of the natives as to the gold found there, and later describes it as the largest and most beautiful he visited. He gives it a new name, moreover, and although it is possible to imagine that he might have sailed past an island already visited without recognizing it, it is difficult to believe that he should have so utterly lost his reckoning as not to have known after sailing nine leagues easterly that he had returned to the

same island from which he had only a few days previous sailed nine leagues west. He landed on both the second and fourth islands, and it is impossible to admit that they were either one and the same, or that they were separated from each other by a mere creek, as are the second and fourth islands chosen by Capt. Fox. The choice of Crooked Island for the second of Columbus necessitates that of Fortune for the fourth, and if the former agrees very closely with the description given, the latter departs as widely from that given of the island of Isabella.

By comparing the preceding solutions of the problem with Columbus' own account of his cruise among the Bahamas, Capt. Fox has convincingly shown their defects, and in basing his own solution on the log of Columbus he has adopted the only method that can be accepted ; but the log evidently contains discrepancies that cannot be reconciled, and in adopting one point, in which the topography apparently agrees exactly with the journal, he sacrifices others no less important. His criticism of Capt. Becher and of Washington Irving is, perhaps, more convincing than is his attempt to lay down a track which shall supplant those proposed by them.

BIBLIOGRAPHIC NOTICES.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE, 1882.

PART V. The physical relations of the Atlantic ocean. Discussion of the monthly barometric variations in different geographical positions and the relation of these changes to other phenomena. Log books of S. M. S. Hertha and Carola. Extract from the Meteorological Journal of the German Observatory. The temperature of the Southern Hemisphere and a comparison of that in the higher latitudes with the same in the Northern Hemisphere. Relation between the winds and currents on the coast of Guinea. Notice of the meteorological expedition to Tanger in 1881. Comparison of the weather of North America and Central Europe for Feb., 1882. Table of the value of the magnetic inclination between 20° N., 25° S., 15° E. and 30° W. Brief hydrographic notices. Meteorological and magnetic tables.

PART VI. Results of recent investigations on deep sea and ocean physics. Explanation of the chart of the frequence and mean paths of barometric minima between the Rocky Mountains and the Ural. Notice of Airy's new method of clearing the lunar distance. Notice of the concurrent testing of marine chronometers at the German Observatory in the winter of 1881–1882. Hydrographic notices and meteorological and magnetic tables.

PART VII. Results of recent investigations on deep sea and ocean physics. Testing of chronometers during the winter of 1881–1882 at Wilhelmshaven. A rough method for determining the polar altitude from two measurements of the sun's altitude. Log notes and hydrographic and meteorological data from various sources. Determination of the temperature, specific gravity and saline contents of the water of the northern part of the Indian ocean.

PART VIII. Record of the ice formation on the German coasts of the Baltic and North seas. Coast surveying by means of the angle of inclination. Log notes and hydrographic and meteorological data from various sources.

PART IX. Deep sea researches by the Travailleur in the Bay of Biscay, Atlantic ocean and Mediterranean sea. Normal points for the typhoon in the Chinese and Japanese waters for 1880. Construction of a coast line in a running survey independently of the current and the speed, together with a contribution to the history of the geometrical solution of the so-called Pothenot's problem. Log notes and hydrographic and meteorological data.

COMPTES RENDUS, XCIII.

No. 2. New method for determining the different constants of a sextant. On the rapidity of the propagation of explosive phenomena in gases. Researches on the products of the decomposition of picrate of potash. Theory of cyclones and an apparatus for demonstrating the theory.

No. 3. The trajectory of cyclones and the transmission of a notice of them by telegraphic cables. On the velocity of propagation of inflammation in explosive gaseous mixtures.

No. 4. On the heat of the formation of explosives.

No. 5. The heat of the formation of explosives, with numerous experiments.

No. 6. On the heat of formation of perchlorate of potash.

No. 7. Note on the employment of a new chlorate of potash powder. Note on a new instrument by which trigonometrical operations may be effected on the earth, with calculations.

No. 8. On the nature of the repulsive force exerted by the sun.

No. 12. On the passage of projectiles through a resisting medium, on the flow of solids and on the resistance of the air to the movement of projectiles.

No. 16. Theory of a fast boat.

No. 17. Detonation of acetylene, of cyanogen and of endothermic combinations in general.

No. 19. Solution of two questions in marine hydraulics. Note relative to the propulsion of ships.

No. 22. Summary of the zoölogical exploration made in the Mediterranean by the Travailleur.

No. 23. Summary of the zoölogical exploration by the Travailleur. On certain meteorological stations which it is proposed to establish in the vicinity of the North Pole.

No. 24. On the international polar expeditions.

VOL. XCIV.

No. 3. On the velocity of propagation of the explosive wave in gases.

No. 4. On the explosive wave.

ENGINEER.

SEPTEMBER 1, 1882. Electricity and Torpedo Warfare. A general paper on protecting a harbor by submarine mines.

"A harbor, to be thoroughly protected, requires not only to be defended by obstructions and mines, but these latter must also be protected by artillery fire. Mines alone can be more or less easily destroyed, unless the enemy in so doing is hampered by an effective fire from permanent coast defenses; nor will forts alone prevent a vigorous commander from forcing a passage, the channel of which has not been obstructed by submarine mines."

Simple *vs.* Compound Engines.

In an editorial commenting on the performances of several simple and compound engines, the claim is made that there need be no difference between the efficiency of the two types—that in practice it is a matter of indifference as regards economy of fuel, whether simple or compound engines are used.

SEPTEMBER 8. Sturgeon's Patent Piston.

The object in view is to jacket the piston, and also to use it as a heater to raise the temperature of the cylinder. This is accomplished by the use of a divided piston, with an arrangement for admitting live steam into the wide spaces between the two sets of rings. Small holes are drilled through from the cylinder into the steam ports, in such a position that when the piston is at the end of the stroke, and the steam port open, the live steam may pass into the interior of the piston, and thus enable it to recover at the end of each stroke whatever it may have lost by condensation during the stroke. Drain cocks are so placed on the cylinder as to drain the piston at the ends of the stroke.

SEPTEMBER 15. Halpin's Compound Condensing Engine.

This engine shows a remarkably small consumption of feed water for power indicated. Apart from the general arrangement of the engine, its chief peculiarities consist in the method employed for securing the maximum benefits from steam jacketing, as well as in the automatic expansion gear. The cylinders are covered along their barrels, and at the ends with ribs, called by the inventor heat ribs, in order to facilitate the transmission of steam heat from the steam in the jacket to the steam in the cylinder, thus preventing, it is claimed, cylinder condensation as far as possible without resorting to superheated steam. Both cylinders are surrounded with one jacket, with covers at the end to enable the pistons to be withdrawn. The following is the performance of one of these engines: H.P. cylinder 9 inches and L.P. 13 inches in diameter, stroke 21 inches, average revolutions 95.9 per minute, developing 31.2 indicated horse-power. The engine was driving a dynamometer placed on the fly-wheel, carrying a load of 27.05 horse-power, thus showing an efficiency of 86 per cent. Steam 65 lbs. pressure, supplied by a portable boiler, grate area 4 square feet, heating surface 326 square feet. The total quantity of feed-water used per hour, per indicated horse-power, was but 17½ lbs., and of this quantity 2¾ lbs. were condensed in the jacket, the coal used, per indicated horse-power, being 1½ lbs. The engine was first run until well warmed up, the fires were then raked out, and firing commenced with weighed coal. Duration of the trial 8 hours.

SEPTEMBER 22. Details of the Compound Engines of the "Leerdam." Efficiency of the Dynamo-Electric Machine.

SEPTEMBER 29. Merchant Ships as War Ships.

An editorial on this subject states that if merchant ships are to be made use of as fighting ships, they must be used, for the time being, for that purpose and no other. To put a big gun or two on the "City of Berlin" is a small matter, but neither the guns nor the ship will prove self-sufficing; they must be used by competent men who could be spared from men-of-war, but it does not appear that the Admiralty would have any competent men to spare.

OCTOBER 6. Official report of Krupp Gun and Target. Experiments at Meppen.

OCTOBER 13. Pickwell's Self-Registering Compass.

This instrument has been subjected to a series of severe practical tests, and has proven a remarkable success. It consists of an ordinary bowl, covered with the binnacle top, with glass windows. Inside the outer bowl, the compass bowl is hung on gimbal rings, in the usual way, and the compass card is seen below the glass cover of the inner bowl. The registering apparatus is fitted in the bowl below the card. It consists of a barrel containing clockwork, which causes a second barrel within the first to revolve at a given speed. The outer barrel is fixed and has two slots cut through on the upper surface parallel to the axis. The compass card also has a slot curved so that some one

part of it is always across one or the other of the straight slots, and as the inner barrel is covered with sensitized paper, whatever course the ship is steered, a ray of light, either from the sun or a lamp, will pass through the small opening at the intersection of the curved slot of the card, with one or other of the straight slots of the barrel, and will produce a black mark upon the paper, more or less distant from the centre of the card, and which from its position will give an exact indication of the course of the vessel at the time. The revolving motion of the drum gives the time the ship's head is on each course, as well as the time such courses are changed. The prepared papers are made for a day of twenty-four hours, but may be made continuous for a period of three months.

ENGINEERING.

SEPTEMBER 1. Electric Accumulators. Automatic Expansion Gear.

A paper read before the Institution of Mechanical Engineers, by Mr. Wilson Hartnell.

Photographing the Trajectory of a moving body.

SEPTEMBER 8. Hill and Clark's Boat-lowering Apparatus.

SEPTEMBER 15. The "Polyphemus."

An editorial on this subject states that the Polyphemus will probably be, for her tonnage, the most costly ship ever constructed. When the changes now necessary have been made, she will cost about a quarter of a million, which is nearly £100,000 more than was estimated.

SEPTEMBER 22. Testing Boiler Tubes and Pressure Gauges.

Admiral Von Henk on Iron-clad Ships.

His conclusions, strengthened by the recent performances before Alexandria, are, first, that unarmored ships cannot maintain a fight of any duration against the heavy guns of ships and forts; secondly, that iron plating is still an effectual defense against the heaviest guns, and consequently indispensable for battle ships; thirdly, rams and torpedoes are formidable weapons in sea-fighting, but cannot supersede artillery as the chief means of defense.

SEPTEMBER 29. Cornish Boiler with Corrugated Furnace Flue.

One striking feature of this boiler is that the flue is not placed with its centre in the vertical centre line of the boiler shell, or, in other words, the arrangement resembles that of an ordinary Cornish boiler set with the axis, which passes through both centre of boiler shell and centre of flue, standing at an angle of 45°, instead of, as is usual, vertically. By this arrangement the bottom is left free for cleaning and inspection, and the active circulation set up in consequence of the wide water-space on one side, against the narrow water-space on the other. The corrugated flue possesses the advantages of great strength and elasticity, increased heat surface, less thickness, hence greater power of transferring heat.

OCTOBER 6. An Electric Launch.

Iron hull 25 feet long, 5 feet beam, 30 inches draught, screw propeller, 350 revolutions per minute, and accommodates twelve persons. The electric engines were simply a pair of Siemens dynamos, of the size known as D^3, and their motive power is furnished by Sellon-Volckmar accumulators. The steering is managed by the person operating the switches, and a speed of 9 knots was attained on the trial trip.

An editorial in this number complains of the practice of designing ships of war at the Admiralty for foreign governments.

OCTOBER 13. Torpedo Boats.

A paper read by Mr. John Donaldson before the Mechanical Science Section of the British Association.

All torpedo boats have been resolved by the Admiralty into two classes: first, those sufficiently large to act independently for harbor and coast defense; secondly, those intended to act as auxiliaries to the ships to which they may be attached.

A model of a second class boat was exhibited 63 feet in length, 7 feet 6 inches breadth, 3⅓ feet draught, displacement 12½ tons, hull of Bessemer steel, divided into ten compartments, so, should one compartment be filled, neither the buoyancy nor stability of the boat will be seriously impaired. This was proven by a collision which took place at Portsmouth between two similar second-class boats, in which the bow compartment of one and the compartment forward of the boiler in the other were filled, but both boats kept afloat, and no damage was done to the machinery and pipe connections.

The machinery consists of a pair of compound surface condensing engines, 8¼ and 13 inches diameters, 8 feet stroke, 150 indicated horse power, at a speed of 653 revolutions per minute, corresponding to a speed of 17.6 knots. The boiler is of the locomotive type, shell of steel and sufficiently strong to withstand a working pressure of 130 lbs. The fire room is entirely enclosed, and air is supplied by a fan driven by an independent engine, which gives a pressure of from two to three inches of water, at a speed of 800 revolutions per minute. The armament consists of two 14-inch Whitehead torpedoes, 14 feet long, laid in troughs, arranged to be projected therefrom by two pistons in steam cylinders. These boats are also fitted with an ejector in the fire room, capable of ejecting 45 tons of water per hour, and a connection by means of which the centrifugal pump of the main engine may be utilized in emptying the bilges to the extent of 30 tons per hour, in all 75 tons, so it is possible to eject the whole displacement of the boat every ten minutes. Experiments with the apparatus at Portsmouth gave excellent results, the torpedoes being projected with a high velocity, and running their course with great accuracy.

A Paper on the Treatment of Steel for the Construction of Ordnance and other purposes. By Sir W. G. Armstrong, C. B., F. R. S.

OCTOBER 20. Continuation of the paper on Torpedo Boats, with detailed drawings of 1st and 2d class boats built by Thorneycroft, for the English, Italian and Danish governments.

FRANKLIN INSTITUTE JOURNAL.

JULY Description of the Edison Steam Dynamo.

In the stations Mr. Edison is establishing in New York for lighting the city, each dynamo machine is run by a separate engine on the same bedplate, and the combination of engine and dynamo is called a "steam dynamo." As this description is by Mr. Edison himself, the greater part of it is given here.

"The foundation of the armature, or the iron core which is built upon the shaft, is made up of sheet-iron disks, separated from each other by sheets of tissue paper and bolted together. This has all the advantages of a solid iron core in strengthening the magnetic field, while it completely prevents the great loss of power by local currents, which would circulate in the iron if it were solid. In the place of insulated wires, the cylindrical face of the armature is made up of heavy copper bars trapezoidal in section, each bar being insulated, and also separated from its neighbors and from the iron core underneath by an air space. The connection between the bars on the opposite sides of the armature to form the electrical circuit is made by copper disks of the same diameter as the core. At each end of the core are one-half as many copper disks as there are bars,

each disk being insulated from its neighbors, and the whole bolted together in such a manner as to form, with the disks of sheet-iron constituting the core, one solid mass. Each disk is formed with projecting lugs on its opposite sides to which the two bars are connected.

"The connections between the opposite surfaces of an armature are of no benefit in generating an electric current, but are a necessary evil, introducing useless resistance into the circuit. By using for this connection copper disks in the manner described, a great weight of copper is disposed in a limited space, and so this useless resistance and consequent loss of energy is reduced to a minimum. This method, moreover, reduces the work to a simple machine construction in which all the parts are duplicates, and the operations can be much cheapened and facilitated by the use of special tools. The spaces between the armature bars admit of a free circulation of air, thereby preventing the accumulation of heat and increasing to an enormous degree the capacity of the machine. The armature is at intervals wound with piano wire over the bars, to resist the centrifugal force developed by their rotation.

"The commutator and brushes of an electrical machine are the parts subject to the greatest depreciation. In this machine all parts of the end of the armature are so constructed as to be easy of access, and they can be quickly and cheaply repaired, or removed and replaced by new parts when necessary. Any accident would require but a short stoppage for repairs. Provision is made for keeping a continuous and rapid circulation of air over the entire face of the armature. The armature is 27.8″ in diameter by 61″ long . . . . .

"The magnet is made up of two immense cast iron 'pole pieces,' between the semi-cylindrical faces of which the armature revolves, twelve cylindrical soft iron cores attached to these pole pieces, and made magnetic by an electrical current circulated in the wire wound around them, and four soft iron keepers, connecting the back ends of the cores. Eight of the cores are attached to the upper pole piece and four to the lower one. The magnet is insulated by cast zinc bases."

The weight of the dynamo is as follows:

Armature and shaft	9,800 pounds.
Two pillow blocks	1,340 pounds.
Magnet complete	33,000 pounds.
Zinc bases	680 pounds.
Total	44,820 pounds.

The engine used is the Porter-Allen $11\frac{3}{16}''$ diameter and 16″ stroke, directly connected and making 350 revolutions a minute. In order to avoid the necessity of maintaining the entire series of bearings absolutely in-line, a self-adjusting coupling is used. The entire weight is

Base plate	10,300 pounds.
Dynamo	44,800 pounds.
Engine	6,450 pounds.
	61,550 pounds.

The article is accompanied by a series of indicator diagrams and calculations illustrating the efficiency of the apparatus. With the engine developing 168.4 H. P., 1050 old lamps were kept somewhat above their normal power in the ratio of $\frac{(99)^2}{(98)^2}$. The loss in friction and in work done in magnet coils and armature was 21.48 H. P., leaving 146.92 H. P. of electrical current, showing an efficiency of 81% in engine and dynamo combined. It is calculated that this energy would light 1375 improved lamps at 16 candle power.

AUGUST. The economy of Single Acting Expansion Engines.

SEPTEMBER. On a newly discovered Absolute Limit to Economical Expansion in the Steam Engine and in other Heat Motors. The Chemistry of the Faure and Plante Accumulators.

NOVEMBER. An improved Feed-Water Heater and Purifier.

The author having found that four-fifths of the sulphate of lime, the injurious ingredient of scale, was precipitated at 250° F. and all of it at 290°, proposes to heat all feed water to at least the lower temperature before admitting it to the boiler. This is done by passing the feed water around the condenser tubes, as in some types of surface condenser, and then by heating it still higher by a coil conveying steam direct from the boiler. The temperature attained would then depend on the boiler pressure. The precipitated salts are collected in a charcoal filter, which can be cleared by a steam blast from the boiler when it becomes clogged by the deposit. The whole apparatus, viz. surface condenser, superheating tube, and filter are enclosed in a wrought-iron shell sufficiently strong to resist the full boiler pressure. An objection would appear to be that while blowing through by the steam blast to clear the filter, the engine would have to work high pressure, the condenser tubes being then surrounded by steam.

GIORNALE DI ARTIGLIERIA É GENIO.

APRIL, 1882. Rifled howitzers and mortars for coast defense and for siege operations. Military applications of the electric light. Horse artillery in conjunction with independent cavalry.

MAY. Military applications of the electric light (conc.) Breaking up guns by means of dynamite. The Italian rules for artillery fire compared with those of the continental armies of Europe.

JUNE. Experiments on the resistance to flexure of materials of construction made at the works of the military engineers at Alessandria. Armaments of the new horse batteries. The resistance of gun carriages for attack and defense.

JULY. Experiments on the resistance of materials to flexure (cont.) The resistance of gun carriages (cont.) On the use of steam in buildings designed for collective use. The nine, ten, twelve and thirteen inch Armstrong cannon.

AUGUST AND SEPTEMBER. Experiments on the resistance of materials to flexure. The perfection of the metallurgy of steel. The fire of field artillery against troops under cover. Elementary ballistics.

INSTITUTION OF MECHANICAL ENGINEERS.

APRIL. Improved Appliances for Working under Water or in Irrespirable Gases.

Devoted principally to an explanation of the Gorman apparatus for diving, and to the Fleuss apparatus for breathing in poisonous gases. In the discussion several instances of the practical use of diving apparatus from vessels were mentioned. The wreck of the Doterel was examined, and all movables, including the whole battery, were recovered by divers, one of them a lieutenant in the Royal Navy, from H. M. S. Garnet. Another case mentioned was the P. and O. steamer Poonah, which found while steaming against a head gale in the Red Sea that the propeller was loose on the shaft. A diver happened to be on board with his apparatus, and made the necessary repairs at once. The British Admiralty keep two classes at Portsmouth and Devonport respectively, for instruction in diving.

The Fleuss apparatus is intended for use in irrespirable or poisonous gases, but could probably be modified so as to admit of use in diving. A kind of knapsack is worn on the back, the upper part of which is occupied by a series of tubes containing caustic potash, while the lower is a reservoir for compressed oxygen, the charging pressure being generally sixteen atmospheres. A mask fitted with two tubes is adjusted over the face, the air vitiated by breathing passing out one of these tubes into the chamber containing the caustic potash, by which all carbonic acid is absorbed, and the nitrogen on being mixed with a proper proportion of oxygen from the reservoir enters the mask through the other tube and is breathed again. This process is repeated as long as the oxygen holds out. A rubber bag connected with the oxygen reservoir is worn on the breast, by which the pressure can always be shown, thus avoiding the risk of the oxygen's failing unexpectedly. This apparatus has been actually used in many of the collieries in England, and enables work to be carried on for two or three hours in fire damp and other poisonous gases.

IRON.

SEPTEMBER 1. The Ocean Trip in a Berthon Boat. The British Association—Southampton Meeting. History of Modern Inventions in the Manufacture of Iron.

SEPTEMBER 8. The History of the Iron and Steel Trades of the United States. Submarine Telegraphy. The Dual Engine.

SEPTEMBER 15. The Naval and Marine Engineering Exhibition at Tynemouth. Arms, Armor and Explosives—Experiments with Xerotive-siccative, Gunpowder and Gun-cotton.

SEPTEMBER 22. Duplex Engine Indicator. The Simplex Motor.

SEPTEMBER 29. The History of the Iron and Steel Trades of the United States, No. III.

OCTOBER 6. Timms and Hodgson's Reversible Boat.

A bolsa or raft, the floats being oval in form, with upper and lower keels or gunwales. It may be made of wood, cork or any other suitable material (light steel rails preferred). Both ends of float are alike, either side may be uppermost, and line of flotation is always below centre of floats. The floats have thin partitions for strength, storage of provisions, water and stores. The deck is of wood and rope. The boat can be stowed and launched in any position. The boat can be used as an anchor-boat for conveyance of stone to be dropped through the deck; and has been highly recommended as a life-boat, as it cannot capsize, can be used as a car to travel on a jackstay in conjunction with rocket lines thrown to a ship, &c. Received the first prize (a silver medal) at the Tynemouth Exhibition.

OCTOBER 13. Cold Dry Air Machines, for Preserving Meats, &c., either on board ship or ashore.

Tate's Electric Steam Valve Closer.

The apparatus can be fitted to any steam engine, whatever the position of the stop valve, and places it under the power of any authorized person on board ship to stop the engines on the instant, thus possibly averting a collision or grounding.

Taylor's Stability Indicator.

An apparatus for showing the initial stability and stowage of ships. It consists of a system of pipes filled with glycerine or other liquid. These pipes are

graduated to show various angles of heel, together with the corresponding metacentric height for each angle.

Iron Ship-building in America. Portable Light Steam Pumping Engine for Watering Ship. The Increased Tenacity in Perforated Test Bars of Steel and Iron. The Transit Instrument.

JOURNAL DE LA FLOTTE.

JUNE 4. Dr. Fleischer's "Hydromotor."

The "Hydromotor" is a vessel 33½ metres in length, five metres beam, and having a tonnage of 105. Dr. Fleischer's system of hydraulic propulsion differs from others in his attempt to suppress all but the simplest machinery, so as to reduce the loss by friction and inertia of working parts. It consists of two cylinders and a surface condenser, with the necessary valve gear. Each cylinder is, in effect, a pump, the steam acting on one side of the piston, the other being connected with the sea. Each cylinder alternately would be full of water, which on the admission of steam would be forced out violently, forming a jet which opening beneath the water line would propel the vessel ahead. The consumption of coal was 111 kilos per hour, the velocity of the jet of water 20.16 metres per second, and the speed attained nine knots.

JUNE 25. Dumont Centrifugal Pumps worked by Brotherhood Engine for the French Navy.

SEPTEMBER 3. Brossard Rotary Engine.

SEPTEMBER 10. Cochran Vertical Boiler. Collisions at Sea.

An article originally published in the Marine Engineer calls attention to the greater damage done in case of collision by the vertical stem now so common in sea-going steamers, over the inclined stem formerly used. In a collision the first shock, with the latter, would be taken by the upper works, and there would thus be less chance of damage being done below the water line, while the straight stem would deliver the whole force of impact at once, below as well as above the surface.

SEPTEMBER 17. Manufacture of Projectiles at Woolwich. (From the Iron and Steel Institute.)

SEPTEMBER 24. Water-Spouts.

A communication of M. Faye to l'Academie des Sciences, in relation to an account of water-spouts observed at Étretat, in 1851. The original account of M. Lalanne describes the occurrence as follows:

"Suddenly, from this uniform and apparently very low arch of thick and homogeneous clouds, several shreds spun out toward the horizon. These shreds—at first irregular in shape, but in each case thicker at the point of juncture with the clouds from which they came, and growing thinner in proportion as they descended—soon assumed a more regular form, and became, as it were, cones, whose bases were in the clouds, and whose apices projected toward the sea. At the moment the point approached the water, the latter began to boil violently over a certain extent, circular in form, and this circle of action became the base of a liquid cone which was raised above the surface of the waves until its apex joined that of the inverted cone proceeding from the clouds above. The rotary movement about the axis common to both cones became more and more sensible, as well as a motion of progression accompanied, and probably occasioned by, a westerly wind, whose force increased as it moved along. Eleven similar spouts were thus formed in less than a quarter an hour, before the eyes of the spectators. . . . .

"Finally, without lightning or thunder and in the midst of a gust of wind, increasing in force and ending in a tempest, we distinctly saw one or two of these spouts break in a flood against the rocks projecting from the western shore of the bay."

"One finds," adds M. Faye, "in the interesting relation of our wise confrère, the powerful influence of the optical delusion which has caused spectators of these phenomena, and sailors above all, to believe that water-spouts pump water from the sea up to the clouds. Here, one also meets that other quite frequent illusion which induces the belief that the spout originates at the same time above and below, in two cones, one of which descends from the clouds while the other springs from the soil, or from the surface of the sea, to meet the first. I will recall here, in a few words, the explanation which I have given for these appearances. A spout is a blowing machine, which blows downward warm air, if the atmosphere of the upper regions where it originates contains neither cirrus nor vesicular water of a low temperature—and cold air in the contrary case. In the first case the spout is invisible, because its contour is only indicated by a condensation of vapor; a condensation which occurs on its flanks when the interior temperature has fallen low enough to reach the dew-point of the strata traversed in its path. It sometimes happens that a spout seems to be interrupted if it crosses a stratum of air relatively cold and dry; I have cited several striking examples. But it also happens more frequently at its first appearance, when seen to descend from above, that the air which it draws downward in a narrowing spiral, is not sufficiently cold to form immediately below a sheath of condensed vapors, such as composes its shape above.

"One sees, none the less, the effect produced by the partially invisible spout, on the earth and on the sea, before it seems to have made the actual contact. The effect produced upon the sea is well known. It describes about the foot of the spout, visible or not, a sort of bush formed by small drops of water being drawn up with violence. The spout acts on the surface of the water like a scoop moved in a circle with great velocity. Thus by a ceaselessly renewed afflux of cold air from above, the sheath of vapors forms around the spout, and then it is that the inferior cone seems to start, mounting upward, to join the superior cone descending from the clouds.

"If one will but place himself in imagination above the clouds, and consider, as from above, the turbulence of the vast rotary movement, which, at that moment, was approaching the coast of France, at Étretat, he will easily imagine the aspect which this obscure depression, formed by the rotary movement in the brilliant sheet of clouds, must have presented. One would have counted eleven spouts, that our confrère saw appear simultaneously, like so many partial gyrations. This example shows, once more, the facility with which partial gyrations are established at the expense of a vast turbulent movement which tends to decompose, or rather to divide itself into detached fragments, without losing its gyratory character.

"This double character is presented, in nature, by gyrations on a vertical axis, alone.

"In the case of terrestrial whirlwinds we view the phenomenon from below, while in the case of the sun we can regard it, as it were, from above."

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

Nos. III and IV, 1882.—On armored ships. Professional patents. Ship-building for a thousand years. New English breech loader. Vavasseur sliding gun carriage. Maitland's retardation ring. Italian coast-artillery material. Table for the estimation of the penetrating power, derived from the formula of the Spezia commission. The manufacture of large cast-steel guns in Russia. New gunpowder in Spain. The new gun of the Spanish navy. Accelerating cannon. Hotchkiss-Nordenfeldt cannon. Sir William Palliser. Two new Argentine torpedo boats. The new Italian boat Batune. Torpedo affairs in

Russia. Items of interest in the German, English, French and Italian navies. Lord Northbrook, First Lord of the Admiralty, on the literary activity of naval officers. Types of ships of the Swedish navy. The Argentine armored ship Almirante Brown. Table of the English and French iron clads. New despatch boat for the German navy. The English torpedo ram Polyphemus. Launching of the double-turreted English ship Colossus. Trial trip of the Brazil monitor Solimoës. Building of a Brazilian gunboat. Launching the Brazilian cruiser Primiero de Março. The new Chinese ram cruisers. Launching of the Chinese armored ship Ting-Yuen. The Russian armored turret ship Peter the Great. Progress and improvement in the building of marine machinery. Experiments on the working of various screw propellers. Boiler explosions and their cause. Electric lighting of ships. The telephone for the use of divers. The Telelog. The explosion on the Triumph, and its connection with the sinking of the Doterel. Compound armor. The steam communication between Europe and Brazil, and steam coasting lines of Brazil. Lighting the coast of the Ottoman Empire. Treatment of steel wire rope on shipboard. List of the ships of the world engaged in trade in 1881, given in per cents. Ships owned in Austro-Hungary in 1881. Activity of the English Life-saving service in 1881. The cause of the changes of color of the Mediterranean sea. Departure of the Austrian observation expedition to Jan Mayen. Argentine-Italian south polar expedition. A floating industrial exhibition. A Sunday launching in Scotland. Sport exhibition in Berlin. Shipping disasters in 1881. New vessels for the United States navy. Venetian cannon. Theory of azimuth errors of control compasses.

Nos. V and VI. The electrical exhibition of 1881 in Paris. Progress in the literature of maritime law. The manufacture of armor plates. The value of armored ships. Welded fire tubes (Fox's system). English naval budget for 1882–3. The mistake about the so-called Niger tables. (We have before referred to these tables as having attracted a great deal of attention among French, Germans and Italians, and we again call the attention of our mathematical students to them.) Scientific expedition of the French navy.

Nos. VII and VIII. Conclusion of the chronometer studies. On torpedo boats. Method for determining the centre of gravity through heeling, without having previously trimmed the ship. Firing experiments at Krupp's factory in March, 1882. Specifications for the building of engines of 2300 indicated horse-power for the corvettes Constance, Canada and Cordelia. Reorganization of the French navy. The Brazilian cruiser Almirante Barroso. Teschernitschew's electric lamp.

No. IX. Progress of the literature of maritime law. The armored ships Nelson and Tegetthoff. The reorganization of the French navy. Telephone indicator for propellers. The third secular jubilee of the Gregorian reform in the calendar. The cost of the Inflexible given in detail. Use of zinc for preserving boilers.

MITTHEILUNGEN U. GEGENSTÄNDE D. ARTILLERIE U. GENIEWESENS.

1882. Part I. Method of blasting under water with freely exposed charges. Italian experiments with the new 19 cm. B. L. cannon, and the 21 cm. B. L.

howitzer. Schneider's universal surveying level. Firing table for the 16 cm. marine gun, Nos. 1 and 3, of Houtoria's system. Product of the artillery establishments and arms for the Russian troops in 1879. Revolving guns for the German Navy.

PARTS II AND III. Notice of the electro-technical exhibition in Paris in 1881. Upon the results of the firing with the field guns in 1880. Investigation of the laws governing the motion of projectiles. The new Dutch field gun. Firing experiments at Beverloo. Bertoldo's repeating mechanism. Estimation of the heat required for warming and ventilation. The Spanish 15 cm. steel-bronze guns. Gun-cotton cartridges in Russia.

PART IV. The development of material for field guns. Submarine blasting in the harbor of Pola in 1881. Manulicher's single charge, B. L. musket. Picard's B. L. musket. New organization of the miners and torpedo service in Russia. The production of compound armor plate at the Dittinger iron works, Germany.

PARTS V AND VI. New B. L. Armstrong gun. Review of the artillery experiments during 1881. Statistical notice of modern men-of-war. The Dutch steel-bronze 7.5 cm. boat howitzers. The Hebler system for muskets. Recent trials at the testing ground at Carabanchel.

RIVISTA MARITTIMA.

MAY, 1882. The naval appropriations. The electric lamp and its applications to ships of war. Report of the Minister of Marine on the state of the Italian mercantile marine, Dec. 31, 1881. Cruise of the Europa. The best composition of a fleet. Artillery and armor. Defense of the maritime frontier.

JUNE. Reflections on naval tactics. The naval appropriations. A necessary school. The electric lamp and its applications to ships of war. Cruise of the Europa. Studies on the best composition of a fleet. The Italian mercantile marine, Dec. 31, 1881. The effect of oil on waves at sea. The coal and the iron industries of England.

JULY AND AUGUST. Reflections on naval tactics. Application of the electric light to ships of war. How to obtain the empire of the seas. Voyage of the corvette Garibaldi from Singapore to Mahé. The large Italian ironclads. The naval appropriations. Telephonic indicator for machinery in motion. Cruise of the Europa. The Austrian navy. The accuracy of reckoning by the log. Attack on armor clad vessels by artillery (trans.) The maritime administration in France. Effect of torpedoes on naval operations.

SEPTEMBER. The naval appropriations. Cruise of the Europa. Hints on naval hygiene. The secular movements of the earth at Gaeta. General scheme for Italian navigation. Speed and carrying capacity of screw propellers. The bombardment of Alexandria.

OCTOBER. Reflections on naval tactics. The naval appropriations. Cruise of the Europa. Formation of cyclones. Studies on the tactical use of the fish torpedo as part of a ship's armament (trans.)

On the proposition for an Italian Naval Institute.

An interesting article devoted to the consideration of the proposal made to organize a Naval Institute in Italy. The advantages sought are recapitulated, but the summing up is very comprehensive—"in a word, to promote the study of naval science, art and literature." Reference is made to the Royal United Service Institution, and its organization, management and utility are thoroughly discussed, and its influence upon the naval system of Great Britain is traced. As a purely naval organization the United States Naval Institute is cited, and the importance of its publications is recognized. Special reference is made to the prize essay for 1881, "The type of armored vessel and cruiser best suited to the present needs of the United States," and to the coincidence between many of the views expressed therein, with the plan afterwards recommended to Congress for the reorganization of the navy.

The subsequent essays are classed as being of minor importance, but clearly demonstrate that "even in America there exists a naval institution for the active and practical solution of the more intricate problems of naval economy."

REVISTA GENERAL DE MARINA.

MAY. The cruise of the Doña Maria de Molina in China and Japan. Elements of naval tactics. Prevention of collisions at night. The Russian Torpedo-boat Batune. Naval organization, strategy. Progress of naval artillery between 1855 and 1880 (concluded). The explosion aboard the Tornado. Naval and Submarine Exhibition at Islington.

JUNE. The cruise of the Doña Maria de Molina. Elements of naval tactics. Merchant and naval marines. Method of determining positions at sea by projecting circles of equal altitude upon a sphere. The Consuelo in dock at Montevideo. Naval and submarine exhibition. The keys of the Straits of Gibraltar.

JULY. The cruise of the corvette Doña Maria de Molina. Elements of naval tactics. The launch of the steamer Birmania. Naval organization, tactics. Naval education in England. Projected reorganization of the U. S. Navy. Notes upon the Paris Electrical Exhibition. Use of the sphere in projecting circles of equal altitude.

AUGUST. The cruise of the Doña Maria de Molina (continued). Elements of naval tactics (continued). The launch of the Birmania (continued). Naval education in England. Notes upon the Paris Electrical Exhibition. Weather indications in the Philippine Islands.

SEPTEMBER. The cruise of the Doña Maria de Molina. Elements of naval tactics. Notes upon the Philippine Islands—the arsenal of Cavite. The introduction of the Whitehead torpedo as a weapon, and its influence upon naval war. English naval estimates, 1882–3. Naval organization, the divisional organization. Notes upon the Paris Electrical Exhibition.

MÉMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

FEBRUARY, 1882. Compound Locomotives in Germany and England. One Cause of Accidents to Marine Compound Engines.

This paper treats of the accident on the ironclad L'Ocean, Oct. 31, 1881, by which the piston and cylinder were completely ruined. On examination, the bottom of the cylinder was found covered with a very hard, adherent scale,

on which the head of the piston impinged, and which weighed in all 5 kilogrammes. Chemical analysis showed it to contain:

Hygrometric water, ...	15.00 per cent.
Different salts of sea water, ...	77.60
Insoluble compounds of iron and alumina, .	6.15
Silica, carbon, organic matter, ...	1.25
	100.00

It has been observed before that deposits are formed with great rapidity in the cylinders of compound engines, in the case of le Laclocheterie over 40 kilos being found in one cylinder. The inspector-general Marielle goes on to discuss the cause of this rapid formation of scale, and is inclined to the view that the salts are carried over suspended in the vapor, which absorbs them, and in being partially condensed in the cylinder, deposits them in an insoluble form. The editor of the *Ingénieurs Civils* says, "We do not intend to discuss here the explanations of M. Marielle, explanations about which he himself has some reservations. It is evident that the salt found in the cylinders came from the boilers, but how is it that they are deposited in the low pressure cylinders and not in the high pressure cylinder? The considerable condensation taking place in the first receivers, from the causes indicated in the report, seems to imply the bad working of the steam jackets of the L'Ocean.

"Is it admissible that the vapor, in the state of vapor, can hold in suspension large quantities of salts? and if this be probable, or if there had been quantities of water projected over, how is it they are not seen in the first cylinder? Further, if the use of separate expansion cylinders has the effect of reducing the interior condensation in these cylinders, how is it, then, that these phenomena are never produced in the ordinary machines, where this condensation ought to be much greater? In any case it will be extremely interesting to know if this thing has been observed in foreign navies, above all in England, where these compound engines may be counted by thousands; and if in the affirmative, what have been the circumstances of the accidents and the explanations given for them?"

Note on the Explosions in the Collieries of Seaham and Penycraig. The Levelling of Rocks under Water. The Economy of Gas Motors.

MARCH. Trials of Steam Engines. Solidification of finely divided Matter through Pressure. Tempering by Compression.

This is a new mode of treating metals, particularly steel, which consists in heating the metal to a red heat, compressing strongly, and maintaining it under pressure until it has cooled completely. The metal thus compressed acquires a great hardness and a molecular closeness and fineness of grain, such that when polished it has the appearance of polished nickel. The compressed steel equals tempered steel in the coercive force as regards magnetism. This property is to be further studied. The author thinks that he produces an amorphous condition as the result of a homogeneity which is due to the complete absence of crystallization, and hence he believes that he can modify these conditions at will and produce any desired results.

The distortion due to a blow compared with that produced by a continuous effort. Method of Calculating Steam-engine Diagrams.

Taking the numbers of Zeuner as a base, M. Quéruel has constructed five tables. 1. The atmospheric pressure in kilogrammes per square centimeter. 2. A comparison of the true numbers with those obtained by the application of Mariotte's law. 3. Absolute work which the vapor can perform under given conditions. 4. The theoretical and actual expansion with work done. 5.

Density and volume of vapor, with logarithms. Reserve valves on feed water pipes of boilers.

MAY. Electrical Aerial Railway. Paris as a Seaport.

This is a consideration of the geographical and mercantile advantages of Paris, and a discussion of the means by which the obstacles to navigation may be overcome.

Discussion of the above project. Discussion of the Formation of Scale in the Cylinders of the *L'Ocean*, referred to in March 18.

M. D. Stapfer says, "All the fatty deposits (oleates and carbonates of iron) which are very abundant when tallow or vegetable oils are used us lubricants, seek, by preference, the bottom of the large cylinders, forming often a very resistant cushion, but they are rarely found in high pressure cylinders. I attribute this to the fact that they are not converted into fat acids, except by the action of highly heated vapor.

"The magma of brown color found at the bottom of the large cylinders contain a certain proportion of calcareous salts, retained probably by a species of filtration. When priming takes place the water leaves scarcely a trace of residue in the small cylinder, but it leaves a calcareous deposit on the sides of the large cylinder, which the segments of the piston are often unable to raise. This phenomenon may be compared to that which takes place when we moisten a hot metal plate with a sponge or brush, wet with water which is slightly calcareous or saline.

"I think that owing to the great pressure, the velocity and density of the fluid is increased in the small cylinder, and the vapor traverses it so fast no deposit can take place; but in the large cylinder when the pressure is often nearly equal to that of the condenser, the velocity of exit is very slight and gives the fluid time to deposit the solid and liquid particles carried with it.

"But in the case of the L'Ocean, if they travel under great expansion they ought not to have priming; then the saline matters could not come from the boiler. The report says that the exhaust does not lead to the condenser, but to the hold. If then the tuyeres of the exhaust have been plunged, by rolling, under the water, we have perfectly explained the source of the product in the large cylinder, it being due to aspiration of the saline water, capable of depositing upon the warm sides of the cylinder a notable quantity of solid matter. M. Marielle has given us reason to conclude that the pipes from the large cylinders should lead to the condenser, as is usual in merchant steamers."

This last explanation seems very reasonable, for if we examine the analysis given above, we see that while we have 77.6 per cent. of sea salts, the iron exists in only small quantities; while there is but an insignificant amount of organic matter, which excludes the idea of the intervention of the fatty matter used in greasing the cylinders.

The Transportation of Electrical Energy. Boiler Explosions during 1880. Depots for Dynamite. Manufacture of Steel Tubes for Cannon.

JUNE. The Panama Canal. Condition of the work in February, 1882. Transmission by Electricity. Boiler Explosions, Theory of their cause.

JULY. New demonstration of the Principle of Virtual Velocities. Ship Canal from Paris to Havre. Stauck's system of Distribution for Valve Engines. Determination of the important points in Indicator Diagrams. The Wood used in construction in the United States. Importation of Coal into Italy. A Large Forging. Electric Light for Lighthouses.

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American Geographical Society. Bulletin V, 1881. Journal, Vol. XIII.

American Society of Civil Engineers. Transactions, June–Sept., 1882.

An Attempt to Solve the Problem of the First Landing Place of Columbus in the New World.

Giornale d'Artiglieria é Genio. Nos. 5–9 (unofficial) and 7–12 (official) 1882.

Harvard University Bulletin. Oct., 1882.

Institution of Mechanical Engineers, England. Transactions, No. 2, 1882.

Institution of Mining and Mechanical Engineers, North of England. Vol. XXI, Part IV.

Journal de la Flotte. Nos. 24–43.

Journal of the Franklin Institute. June–Nov., 1882.

Journal of the Military Service Institution of the United States. No. 10.

Journal of the Royal United Service Institution. No. 116.

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Reunion des Officiers, Bulletin. Nos. 23–42.

Rivista Marittima. 1882. June–Oct.

Société des Ingenieurs Civils. Mémoires. Feb. July, 1882, except April.

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Journal of the Franklin Institute. June–Nov., 1882.

Journal of the Military Service Institution of the United States. No. 10.

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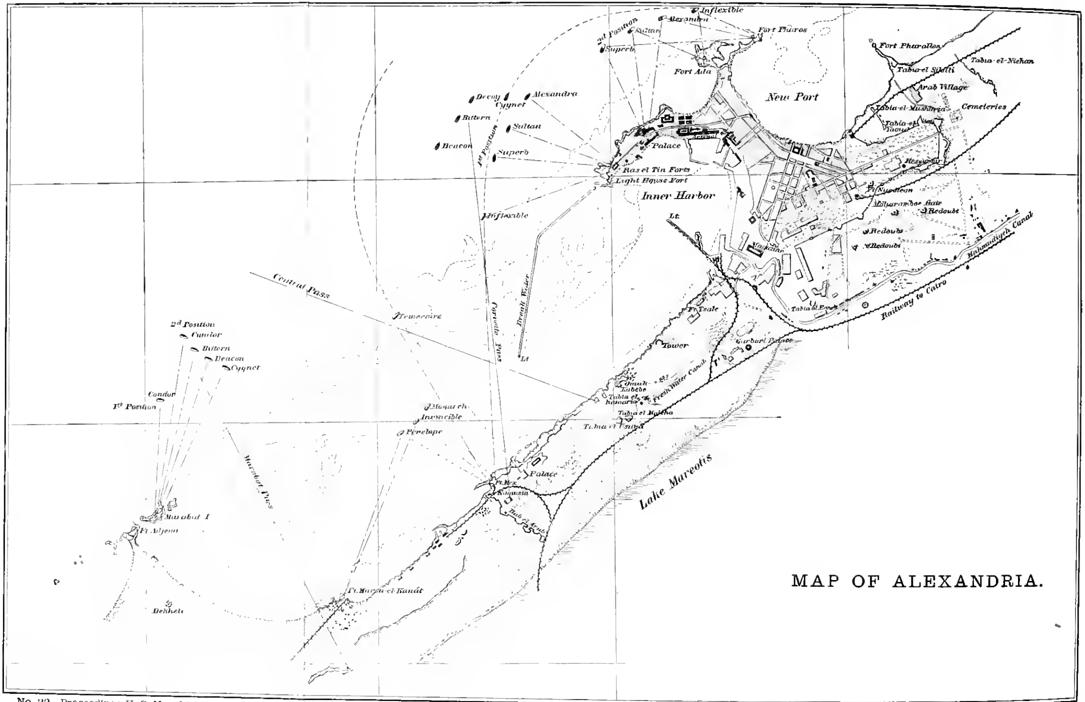
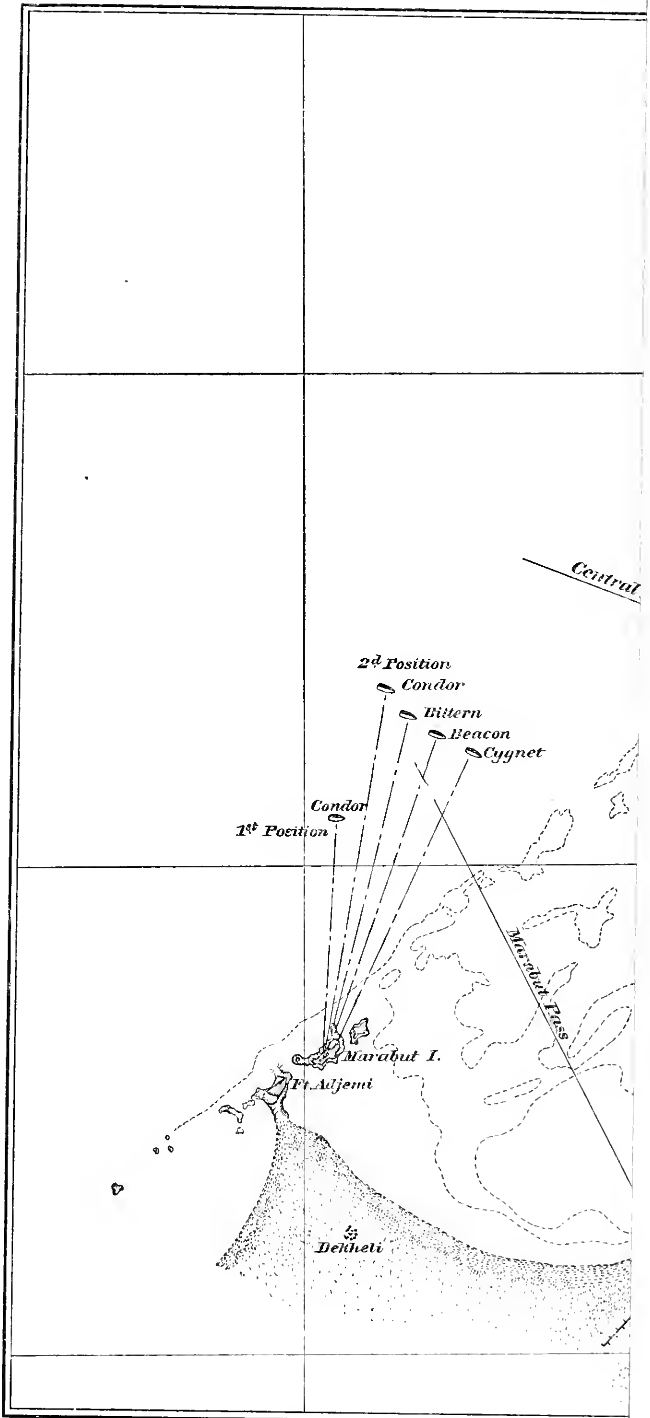


MAP OF ALEXANDRIA.


Central
2d Position
Condor
Bittern
Beacon
Cygnet
Condor
1st Position
Marabut Pass
Marabut I.
Ft. Adjemi
Dekheli

THE PROCEEDINGS

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JANUARY, 1883.

OPERATIONS OF THE BRITISH NAVY AND TRANSPORT SERVICE DURING THE EGYPTIAN CAMPAIGN, 1882.*

THE BOMBARDMENT OF ALEXANDRIA.

By Ensign Charles C. Rogers, U. S. N.

With the political events which preceded the massacres at Alexandria on June 11, 1882, this article has nothing to do. That day it was decided that the rebellion in Egypt, and its leader, Arabi Pasha, must be crushed. The English government determined to undertake the work of restoring order in Egypt single-handed, and thus maintain European influence in the East. The Channel Squadron, under Vice-Admiral Dowell, C. B., was ordered to Alexandria, and the Reserve Squadron, under Rear-Admiral H. R. H. the Duke of Edinburgh, to Gibraltar; but the latter was recalled, Rear-Admiral Hoskins, C. B., in the Penelope, being alone ordered to Alexandria, and temporarily attached to the Mediterranean Fleet under Sir Beauchamp Seymour, G. C. B. At the same time Rear-Admiral Sir William Hewett, K. C. B., V. C., was ordered to Suez with the Ruby, Dragon, Eclipse, Mosquito, and Seagull. In addition to these ships, Sir Beauchamp Seymour had under his orders the Alexandra, Inflexible, Téméraire, Monarch, Inconstant, Sultan, Superb, Orion,

* The material for this article has been kindly supplied from the files of the Office of Naval Intelligence, Bureau of Navigation, Navy Department, where it has been compiled from apparently creditable sources.

Invincible, Minotaur, Northumberland, Agincourt, Achilles, Penelope, Carysfort, Tourmaline, Hecla, Thalia, Cygnet, Coquette, Condor, Decoy, Don, Beacon, Dee, Bittern, Ready, Cockatrice, Tamar, Supply, Chester, Iris, Helicon, and Salamis. These ships were variously distributed at Alexandria, Port Said, Ismailia, Suez, Cyprus and Malta. The Monarch, Invincible, Penelope, Alexandra, Sultan, Superb, Inflexible, Téméraire, Condor, Cygnet, Bittern, Beacon, Decoy and Helicon were at Alexandria; this fleet being further augmented by the subsequent arrival of the Hecla, torpedo vessel. Some were anchored in the inner harbor, others outside. Arabi Pasha commenced constructing and arming the Alexandrian forts, mounting heavy guns in sight of the English fleet. Every day the muzzles of new guns were seen from the ships, and preparations were even made by Arabi to block the mouth of the harbor. Admiral Sir Beauchamp Seymour was directed to demand the immediate disarmament and destruction of the menacing works, and on July 6th sent in an ultimatum, which was followed by another on July 9th, the purport of which was that unless certain forts were dismantled within twenty-four hours the English fleet would open fire upon them. The Egyptian authorities attempted to gain time to complete their works. On the evening of the 10th July the English ironclads steamed out of the inner harbor and took up positions opposite the different works.

The armament of this force was as follows:

SHIPS.

Ship's Name.	Guns.										Armor. Max. in inches.	Draught of water. Feet.	Tonnage.	Crew
	80-ton, 16-inch.	25-ton, 12-inch.	25-ton, 11-inch.	18-ton, 10-inch.	12-ton, 9-inch.	9-ton, 8-inch.	90 cwt. 7-inch.	64 Pdr.	40 Pdr. Armst'g.	20 Pdrs.				
Inflexible (turret).....	4	...	...	...	...	...	...	...	...	...	24 to 16	$25\frac{1}{2}$	11,880	484
Monarch (turret)......	...	4	...	...	2	...	...	...	...	...	10 to 8	$26\frac{1}{2}$	8,320	515
Téméraire (barbette)	...	...	4	4	...	...	...	...	...	...	11 to 8	27	8,540	534
Alexandra.......	...	...	2	10	...	...	...	...	...	...	12 to 8	$26\frac{1}{2}$	9,290	674
Sultan	...	...	...	8	4	...	...	...	...	...	9 to 6	$27\frac{1}{2}$	9,290	400
Invincible.	...	...	...	...	10	...	...	...	...	...	8 to 6	23	6,010	450
Superb..................	...	...	...	12	...	...	4	...	...	...	12	$25\frac{1}{2}$	9,170	620
Penelope...............	...	...	...	...	...	8	...	...	3	...	6 to 5	$17\frac{1}{3}$	4,470	233
Condor..........	...	...	...	...	...	...	1	2	...	...	Unarmored Gun Vessel.	...	780	104
Bittern........	...	..	...	...	...	...	1	...	2	...	"	...	805	90
Beacon..................	...	...	...	...	...	...	...	2	...	2	"	...	603	...
Decoy	...	...	...	...	...	...	...	2	...	2	"	...	430	59
Cygnet..................	...	...	...	...	...	...	...	2	...	2	"	...	455	50
Totals	4	4	6	34	16	8	6	8	5	6	....	...	......	4213

Name, Nature, and Classification.			Initial Velocity. Chilled Shot.	Initial Velocity. Common Shell.	Muzzle Energy. Chilled Shot.	Muzzle Energy. Common Shell.	Penetration. (Iron.) At 500 yards.	Penetration. (Iron.) At 1000 yards.
			Feet.	Feet.	Foot Tons.	Foot Tons.	In.	In.
Muzzle-loading, built-up guns, Woolwich pattern.	Armor piercing.	16-inch, 80 ton.......	1520	......	27,213	...	27.5	26.4
		12-inch, 25 ton........	1180	......	7,030	...	13.9	13.1
		11-inch, 25 ton..	1315	......	6,415	...	13.8	13.1
		10-inch, 18 ton........	1364	......	5,160	...	12.7	12
		9-inch, 12 ton..	1420	......	3,496	...	10.4	9.6
		8-inch, 9 ton.........	1413	......	2,492	...	9.8	9.5
		7-inch, 90 cwt........	1525	......	1,855	...	8.8	8.6
		64 pdr., 64 cwt. shell	......	1383	......	848	...	...
Armstrong Breech-loaders.	Shell.	40 pdr..................	......	1180	......	378	...	...
		20 pdr..................	......	1000	......	142	...	...

ERRATUM.

In table of armament of ships, on p. 524, the guns of the Superb should read 16 18-ton 10-inch, and not, as given in table, 12 18-ton 10-inch and 4 90-cwt. 7-inch. This changes the totals to 38 18-ton 10-inch and 2 90-cwt. 7-inch guns.

Invincible, Minotaur, Northumberland, Agincourt, Achilles, Penelope, Carysfort, Tourmaline, Hecla, Thalia, Cygnet, Coquette, Condor, Decoy, Don, Beacon, Dee, Bittern, Ready, Cockatrice, Tamar, Supply, Chester, Iris, Helicon, and Salamis. These ships were variously distributed at Alexandria, Port Said, Ismailia, Suez, Cyprus and Malta. The Monarch, Invincible, Penelope, Alexandra, Sultan, Superb, Inflexible, Téméraire, Condor, Cygnet, Bittern, Beacon, Decoy and Helicon were at Alexandria; this fleet being further augmented by the subsequent arrival of the Hecla, torpedo vessel. Some were anchored in the inner harbor, others outside. Arabi Pasha commenced constructing and arming the Alexandrian forts, mounting heavy guns in sight of the English fleet. Every day the muzzles of new guns were seen from the ships, and preparations were even made by Arabi to block the mouth of the harbor. Admiral

	80- 16-	25 12-	2 11-	18 10	12 9-	9- 8-	90 7-	64	40 A	20	A	D W	T	C
Inflexible (turret).....	4	...	...	...	...	...	...	...	...	...	24 to 16	25½	11,880	484
Monarch (turret)........	...	4	...	...	2	...	...	...	...	...	10 to 8	26½	8,320	515
Téméraire (barbette)	...	...	4	4	...	...	...	...	...	...	11 to 8	27	8,540	534
Alexandra.......	...	...	2	10	...	...	...	...	...	...	12 to 8	26½	9,290	674
Sultan	...	...	...	8	4	...	...	...	...	...	9 to 6	27½	9,290	400
Invincible.	...	...	...	...	10	...	...	...	...	...	8 to 6	23	6,010	450
Superb..................	...	...	...	12	...	...	4	...	...	...	12	25½	9,170	620
Penelope..............	...	...	...	...	...	8	...	...	3	...	6 to 5	17⅓	4,470	233
Condor.........	...	...	...	...	...	...	1	2	...	...	Unarmored Gun Vessel.	...	780	104
Bittern........	...	..	...	...	...	...	1	...	2	...	"	...	805	90
Beacon..................	...	...	...	...	...	...	...	2	...	2	"	...	603	...
Decoy	...	...	...	...	...	...	...	2	...	2	"	...	430	59
Cygnet..................	...	...	...	...	...	...	...	2	...	2	"	...	455	50
Totals	4	4	6	34	16	8	6	8	5	6	....	...	......	4213

Guns.

Name, Nature, and Classification.			Projectiles. Entire weight. Chilled.	Projectiles. Entire weight. Common.	Projectiles. Entire weight. Shrapnel.	Projectiles. Weight. Burster for Chilled.	Projectiles. Weight. Burster for Common.	Powder Charge. For Steel and Chilled Shot.	Powder Charge. For Common Shell.	Powder Charge. Ordinary Firing.	Initial Velocity. Chilled Shot.	Initial Velocity. Common Shell.	Muzzle Energy. Chilled Shot.	Muzzle Energy. Common Shell.	Penetration. (Iron.) At 500 yards.	Penetration. (Iron.) At 1000 yards.
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Feet.	Feet.	Foot Tons.	Foot Tons.	In.	In.
Muzzle-loading, built-up guns, Woolwich pattern.	Armor piercing.	16-inch, 80 ton.......	1,700	...	...	11.25	......	370	...	...	1520	......	27,213	...	27.5	26.4
		12-inch, 25 ton.......	600	497	497	6.9	37.7	85	67	55	1180	......	7,030	...	13.9	13.1
		11-inch, 25 ton..	535	536	...	5.5	29.7	85	70	60	1315	......	6,415	...	13.8	13.1
		10-inch, 18 ton.......	400	398	404	4.5	20.25	70	60	44	1364	......	5,160	...	12.7	12
		9-inch, 12 ton..	250	250	255	2.5	19	50	43	30	1420	......	3,496	...	10.4	9.6
		8-inch, 9 ton.........	180	182	180	2.5	14.5	35	30	20	1413	......	2,492	...	9.8	9.5
		7-inch, 90 cwt.	115	117	116	...	8.75	30	22	14	1525	......	1,855	...	8.8	8.6
		64 pdr., 64 cwt. shell	......	64	66	...	7.2	...	10	10	......	1383	... ..	848	...	...
Armstrong Breech-loaders.	Shell.	40 pdr........	......	38	40	...	2.5	...	5	5	......	1180	......	378	...	...
		20 pdr........	......	20.5	20	...	1.2	...	2.5	2.5	......	1000	......	142	...	...

Besides these pieces there were several Gatling and Nordenfeldt guns distributed through the fleet. Against the onslaught of this formidable armament was opposed the Egyptian ordnance, a large portion of which was obsolete and ineffective.

The following table shows the strength of the more important forts opposed to the fleet.

Name of Fort.	10-inch M. L. Rifle.	9-inch M. L. Rifle.	8-inch M. L. Rifle.	7-inch M. L. Rifle.	15-inch Smoothbore.	10-inch Smoothbore.	9-inch Smoothbore.	8-inch Smoothbore.	6-inch Smoothbore.	13-inch Mortar.	11-inch Mortar.
Ras-el-Tin...	1	4	2	1	5	3	2	...	22	6	...
Ada.	1	3	1	...	...	13	...	...	...	3	...
Pharos.........	1	3	2	...	...	...	...	4	39*	6*	...
Mex†..........	1	1	3	...	2	4	...	...	5	3	3
Marabout.....	2	2	...	...	...	...	...	...	30	5	...
Total..........	6	13	8	1	7	20	2	4	96	23	3

Fort Mex, including the line of earthworks extending eastwards, contained thirty-one pieces, of which four were of the larger calibre.

Three smaller works guarded the shore as far as the interior basin of the old fort, and were armed with twenty-five pieces. This line of works, presenting a front of fifty-six guns, commanded the entrance to the harbor. It was this point which the Egyptians began to arm under the eyes of the fleet, the battery of Fort Mex proper being the most important of all this line of defense.

The most westerly of the forts was Marabout, which was not regarded as of primary importance, on account of its distance from the city. Behind it is Fort Adjemi, the armament of which is unknown. It does not appear to have engaged in the action.

Between Forts Marabout and Mex is another work, Mars-el-Kanat, which was not occupied. It was, however, bombarded by the fleet.

Lighthouse fort is situated near Eunostos Point, and commands the inner harbor and sea outside of the breakwater.

* The mortars and fourteen of the 6-inch guns were mounted in barbette. The remaining twenty-five 6-inch guns were in casemates.

† Strength of the sea face of Fort Mex *proper*.

A line of coast batteries extends from the lighthouse past the Ras-el-Tin fort and palace, to near Fort Ada. These were the Ras-el-Tin batteries, the armament of which was intended to be seventeen guns, four of large calibre. At the end of this line was an 8-inch Armstrong gun, mounted upon a Moncrieff carriage.

East of the lighthouse, upon a reef connected with the land by a narrow causeway, stands Fort Ada. Farther on at the extremity of the peninsula is Fort Pharos, commanding the entrance to the new port.

The forts if well manned may be said to have been of a character extremely formidable for unarmored ships. The rifled guns were of the same type as those used by the English, having been purchased from Sir W. Armstrong & Co.

The projectiles fired were chilled shot of the latest description.

The 18-ton guns might penetrate fourteen inches of iron at the muzzle under favorable circumstances. By the table it will be seen that this means the possibility of penetrating, at close range, some part of the armor of all the vessels of the English fleet, excepting that of the Inflexible; but these guns were few in number, and the ships were not likely to engage closer than 1000 yards. Again, it was improbable that the shots would strike direct, and hence the chances were that even the 10-inch projectiles would not penetrate most of the armor. The 9-inch guns were hardly likely to penetrate any except the Sultan, Invincible, and Penelope, and the damage done to ironclads by lighter rifled guns and smoothbores would not be material. However, these latter do not seem to have been used in the engagement with even all the effect possible.

The guns of the shore batteries could be dismounted by good firing, they having no great advantage in command, nor was their power sufficient to contend with the ships. The two most important elements against the full use of these guns were, the lack of experienced gunners, and their elevation above the water not being sufficient to enable the English decks to be struck. Such was the state of the defenses of the city on the eve of the bombardment; the garrison charged with its defense has been estimated at from 7000 to 8000 men.

The attack against these four miles of fortifications was made from several points. The Admiral's idea appears to have been to commence with all those which commanded the sea front and the entrances to the harbors. The following plan of attack was issued by Admiral Seymour to his commanding officers: "The Admiral's

instructions are, that there will be two attacks. The Invincible, Monarch, and Penelope will attack from the inside of the harbor, and the other ships will operate from the outside. The action will commence by signal. The ship nearest Fort Ada to the northeast will fire a shell into the earthwork. Upon the fort making any reply, the outside squadron must destroy the Ras-el-Tin batteries, afterwards moving eastwards and destroying Forts Pharos and Silside. The Inflexible will engage the Mex forts; the Superb, Sultan, and Alexandra will flank the works on Ras-el-Tin. The gun-vessels and gunboats will remain outside and keep out of fire until a favorable opportunity offers itself for making an attack."

Until the night of Monday, July 10th, the Monarch and Inflexible lay in the inner harbor, and none of the ships indicated the stations from which they would open fire. During the night each vessel quietly took the station at which action commenced in the morning at 7 o'clock. The Invincible, with the Admiral on board, the Penelope and Monarch had then moved into position to bombard Fort Mex—1000 to 1500 yards W. by N. of Mex—inside the Boghaz Pass. The Alexandra, Superb, and Sultan formed outside on a northeast line, from 1500 to 1900 yards W.½N. of Eunostos lighthouse. They were within easy range of the Ras-el-Tin forts on the southwest portion of the peninsula. The Inflexible lay in Corvette Pass, 3700 yards N. by W. from Fort Mex, and the Téméraire in Boghaz Pass, 3500 yards NNW. from Fort Mex. These two vessels occupied the central position, as it were, of an echelon of squadrons, and could, therefore, assist in any part of the attack, though sometimes at very long range. The position of the Inflexible was admirably selected for utilizing her great power to the best advantage, for while able to shell the Mex forts at a moderate range with one turret, she could simultaneously direct a terribly effective flanking fire on the Ras-el-Tin batteries with the other. The small vessels kept under way, so as to be ready to avail themselves instantly of any favorable opening.

Beginning from the northeast and going to the southwest, the ships then lay as follows: Alexandra, Sultan, and Superb forming the first group, Inflexible and Téméraire the centre group, Penelope, Invincible, and Monarch the third group, the gunboats being outside of all.

At 5.15 A. M. July 11th, the despatch-vessel Helicon was seen steaming rapidly towards the British fleet. As she approached the Invincible she signalled that she had Turkish officers on board. When she came alongside it was learned that the Turkish officials

had been trying all night to find the flagship and that they carried a letter for the Admiral from the Ministry. In this communication the latter deprecated hostilities and offered to dismount their guns to give satisfaction to the British demands. The Admiral replied that the time for negotiations had passed; his demand had been that the outside forts should have been dismantled by five o'clock of the evening before, and the present proposal to dismount their guns could not be entertained for an instant.

At 6.20 the ships of the squadron signalled "all ready." The Téméraire had ventured so far into Boghaz Pass as to take ground at 6 A. M. The Condor at 6.20 was sent to her assistance. The firing upon the fortifications was opened at 7 o'clock, the first shot being fired by the Alexandra at the recently armed earthworks known as the Hospital battery. Four minutes afterwards a general signal was hoisted by the Invincible to attack the enemy's batteries. The signal was no sooner made than the Invincible and Penelope, then at anchor, and the Monarch, under way, immediately opened fire on the Mex batteries. These vessels took the brunt of the battle against the earthworks at Fort Mex and toward Mars-el-Kanat, supported at longer ranges by the Téméraire, still aground in the Boghaz Pass, directing her fire on the Windmill battery, and by two guns of the Inflexible, which, as has been said, divided her fire between Fort Mex and Ras-el-Tin. The Superb, Sultan, and Alexandra engaged Forts Pharos and Ada at first under steam, moving NE. by E.—then SW. by W. at a range of 1000 to 1500 yards. The Egyptians were evidently waiting in readiness, for they replied at once, and at 7.10 all the armor-clad ships and forts were engaged, the Invincible, Penelope, and Monarch employing their Gatlings as well as their heavy guns. At 7.30 the gunboat Cygnet opened fire on Fort Ras-el-Tin. Until about 8 o'clock the attack continued without any marked change in the disposition of the forces. The sun was rather in the eyes of the English gunners, especially of those of the Invincible, Monarch, and Penelope, whose fire was to the eastward, while the wind enveloped the ships in smoke, so that the guns had continually to wait for it to clear away, or were fired by directions from the tops. The gunners at Fort Mex did excellent firing, the Invincible being repeatedly struck, sometimes close to the water-line, but by shot incapable of penetrating it.

The Egyptian batteries replied steadily and rapidly. The fire of the ships was at first wild, but afterwards it improved and became

very good. Throughout the action it was very deliberate. The rush of the heavy projectiles through the air resembled the rumble of distant thunder. At 8 o'clock the electric broadsides from the four ships attacking Pharos and Ras-el-Tin were beginning to tell with great effect. The accurate practice of the Inflexible with her four 80-ton guns was apparent on the Ras-el-Tin and Mex forts. The lighthouse was struck twice.

At 8 o'clock the Téméraire was afloat, and Lord Charles Beresford with the Condor left her for Marabout, and in ten minutes was attacking, single handed, one of the strongest forts of Alexandria, whose two 10-inch muzzle-loading rifle guns had been annoying the Penelope, Invincible and Monarch. The shell of these guns fell in excellent line from ten to thirty yards short. This fort the Condor had all to herself for an hour, when the Bittern and Beacon were signalled by the flagship to go to her aid. The Cygnet and Decoy shortly afterwards joined them. The Condor at first took up her position on the side of the fort nearest the harbor, and thus escaped the fire of twelve guns on the north front. She moved continually, firing her three guns and presenting as small a target as possible. A Nordenfeldt gun in her foretop was fired with excellent effect, a perfect hail of shot being poured into the embrasures of the fort, and driving the Egyptians from their guns. These two facts account for her not being hit once. So well-directed was the fire of the Condor, so great was its effect, that the Admiral publicly expressed his appreciation by signalling from his flagship "Well done, Condor!"

The gunboats virtually silenced Fort Marabout, for, at 11 A.M. on the Admiral's signal to cease fire, it was left by them with only one gun that could be worked. This attack of the gunboats upon the Marabout forts was, to an observer, the most interesting feature of the engagement. At 8.30 a magazine in Mars-el-Kanat was blown up by the fire of the Monarch. At 10.30 the Alexandra, Superb, and Sultan anchored in a line off Lighthouse fort at about 800 yards from Fort Ada, and poured in a steady fire all along the line of works extending from Pharos to Ras-el-Tin. From 9 to 10 the Téméraire played on Fort Mex; all the guns in that fort having been silenced except four, which were well worked and well under cover. By 10.30 one of these guns was dismounted; the remaining three maintained their fire. These guns were concentrated on the Invincible, their shot striking her several times, often quite near the water-line. Before they were silenced six men of the Invincible were wounded. By 11

the fort was in ruins and its guns all silenced, when the Monarch was signalled to go close in shore and dismantle the fort at close quarters. In the Fort Mex magazine, which contained 350 tons of powder, an unexploded shell fired by the Monarch was found after the engagement.

At 10.30 the Khedive's palace, situated behind Ras-el-Tin, was on fire, and soon after a rifle-tower close to it was discovered to be in flames. The majority of the guns along the lines were silenced, and the powder magazine in Fort Mex was blown up by a shell from the Monarch. At 2 o'clock volunteers were called for by the Admiral to land at Fort Mex and destroy the guns. A party of five officers and twelve men pulled in and destroyed the guns, spiking six and destroying two by bursting them with gun-cotton. They met with no opposition, and returned safely to the flagship.

The Téméraire fired her guns with good effect from her position at the entrance of Boghaz channel, her range being 4000 yards. Her barbette guns were handled very deliberately and their fire was very accurate, probably the best in the fleet. The guns disappeared before their shot struck the object. At 10.20 she was signalled to cease firing, and remained silent till 2.30, at which time she had joined the Invincible, which had steamed around and taken up a position north-east of the Alexandra squadron. This squadron had been firing steadily at Fort Pharos all the morning, but had not succeeded in silencing it. When the flagship signalled "Can destroy Pharos," both the Invincible and Téméraire threw the weight of their fire upon it and Ada, the shells of the former telling with great effect on the masonry. The magazine in Fort Ada was blown up by a shell from the Superb, and the guns silenced. The Egyptians continued their fire at intervals till 4 o'clock, by which time most of their guns were silenced, even those of Pharos and the Moncrieff battery, the latter of which had held on stubbornly.

The ships continued shelling the fortifications, occasionally using shrapnel. The inner squadron directed its attack especially to the eastern harbor works. By 5.30 all the forts were silenced, the signal to cease firing was made, and the action ended, having lasted ten hours and a half from the time the first gun was fired.

In the evening all the vessels drew off the shore and assembled in squadron order for the night. All the sea batteries were destroyed by this day's work. In Fort Mex the smoothbores were uninjured, but all the rifles were dismounted. The latter were struck on the

left side, the effect being very curious. The 8-inch rifle was hit direct about two feet forward of the trunnions, and the tubes displaced one-quarter of an inch; the weld in the last turn of the B tube was imperfect, about eighteen inches of the coil projecting straight out from the piece. The force of the blow had overturned the slide, the carriage and gun were disconnected from the slide and from each other and lying on the ground. Two other rifles were struck obliquely forward of the trunnions. In both cases the carriages were torn to pieces and the guns fell through the slides, each bracket on its own side. Large quantities of ammunition and hundreds of torpedoes were found in the fort uninjured.

The effect of the fire upon Fort Pharos was tremendous; the masonry was completely riddled. Many of the guns in the casemates were dismounted, but the rifled guns on the parapets escaped uninjured; though one was temporarily disabled by earth thrown under the slide by a shell.

Many of the Egyptian guns were disabled by their own recoil. The pivot bolts were drawn out, the guns thereby thrown off their tracks, and hence training was rendered impossible.

Many of the explosions of shells from the ships were premature. Large numbers of percussion shells had "tumbled" and were found unexploded. By far the greater number of these shells were armor-piercing. The coral and sandstone cement of the fortifications did not present sufficient resistance to explode them. Against embankments the 16-inch shells of the 80-ton gun were no more effective than those of less calibre.

The Egyptians had fought their guns to the last, but the fire of the fleet was crushing and the weight of its metal so superior that their resistance, though very creditable, was yet ineffective. Had they used shell instead of round shot, the casualties in the fleet might have been much greater.

During the night of the 11th the Harem palace continued to burn and the flames rose high from the great conflagrations raging in the town.

The anticipations of the officers of the fleet were that the events of the next day would be quite as momentous as those of Tuesday. Fort Marabout and the battery, with the Moncrieff battery at Ras-el-Tin, were still capable of giving trouble, and when these were silenced there was the serious work of dealing with the inner forts.

After daybreak on the 12th the wind rose, producing a long heavy

swell which caused the ironclads to roll considerably at their anchorages. It was seen that a flag of truce had been hoisted by the Egyptians.

At 8 A. M. the captains of the fleet were summoned to a consultation on board the Invincible, and the result of their deliberations was that the sea was too heavy for serious operations; that the rolling of the ironclads would unsettle the aiming of the guns, and the town behind the forts might suffer severely from shot and shell flying too high. The intended attack upon Fort Marabout was therefore postponed, but the Téméraire and Invincible were directed to watch the Ras-el-Tin and Ada batteries.

At 10.30, the Téméraire signalled "Parties of soldiers at work at the Moncrieff battery near Fort Ada." The Téméraire asked "Shall we fire upon them to prevent repairs?" The Admiral signalled his consent, and the two ironclads opened fire. Six rounds of shot and shrapnel were fired. All took effect, notwithstanding the roll of the vessels. The troops engaged upon the work at once abandoned it and the firing ceased.

The white flag was now hoisted at the lighthouse, and the Bittern was sent inside with the flag-lieutenant on board to inquire the intentions of the government. After she had steamed off, the Téméraire signalled, "The party of men whom we saw working at the hospital battery dispersed after our last shrapnel shell was fired, and took refuge in the casemates close by. We saw about 160 men armed with rifles running towards Lighthouse fort. They carried bags. We saw also an Egyptian general, apparently Arabi himself, surrounded by his staff."

At 3 P. M., the Bittern was steaming out of the harbor. As she came out she signalled "The negotiations have failed; I have accordingly informed the authorities on shore that you will engage the batteries at half-past three."

When the flag-lieutenant arrived on board the flag-ship he reported that the evident object of the hoisting of the flag of truce was to gain time; that when the Bittern went in, large bodies of troops were evacuating the barracks behind the forts, going out in full marching order; that the ministers had no proposals of any kind to make, that he informed them he had not come to offer conditions, but to receive proposals; that Fort Mex must be occupied by the British troops and Fort Marabout destroyed. They replied that Fort Marabout was already evacuated, but could give no definite

answer as to Fort Mex. The military governor who had been in command of the city during the action conducted the negotiations. He was informed by the flag-lieutenant that the Admiral would allow the forts to be evacuated by the troops with their rifles and all honors of war; but unless these terms were complied with no negotiation whatever could be entered upon. Finding that no agreement could be arrived at the Bittern left, and the Egyptians hauled down their flag of truce. At this time the Monarch, Invincible, and Penelope were still anchored off Fort Mex. The other vessels of the fleet lay at some distance off, in readiness to come in and complete the destruction of Pharos and the other sea batteries when the signal was given. The fleet was strengthened by the arrival of the Achilles.

Orders were given to the Téméraire and Superb to fire two rounds each at Fort Pharos.

At 5 P. M. the Invincible fired a nine-inch shell at Fort Mex. The shell struck the point aimed at, and in a short time flames broke out from a building. The ship was rolling heavily, though the atmosphere was clear. There was no reply, nor any sign of life in the fort. A few minutes after this shot was fired a white flag was again hoisted.

The Helicon was sent in to inform the authorities that the Admiral accepted the flag of truce, but that it would be the last one to which he would agree, and that henceforth he would regard the hoisting of a white flag as signifying unconditional surrender and would act accordingly.

After an absence of some length she returned with the information that no communication had been opened with the enemy, that the arsenal was deserted, and so far as could be seen the whole town had been evacuated.

The Admiral made an effort to ascertain the real state of things by sending the steam pinnace, with an armed crew, to go up the harbor to reconnoiter. Mr. Ross, one of the purveyors to the fleet, volunteered to land and make his way alone into the town, being perfectly acquainted with the locality. On reaching the wharf all was quiet, and Mr. Ross sprang ashore and proceeded alone on his dangerous mission. The pinnace pushed off a few yards and remained stationary. Mr. Ross traversed the streets, saw no living being, and realized that that quarter of the town was wholly deserted. In a quarter of an hour Mr. Ross returned, and when the news of the evacuation was known on board the Invincible, it was realized that

Arabi, by the two exhibitions of the white flag, had succeeded in withdrawing his troops from the city.

The conflagration alluded to had begun at 6 P. M. At that time the mob began to pillage and destroy. Dense smoke was seen rising from Alexandria over two quarters, and another fire had just broken out. No military were visible from the ships, and only a few people could be seen on shore, hurrying to a village close by the ruins of Fort Mex. At 9 P. M. the Sultan, Superb, Téméraire, Inflexible, and Achilles were lying off the New Port in readiness for action the next day.

The Turkish yacht was lying near the Khedive's palace at Ramleh, close in shore, to save the Khedive and his family in case of need. The Chiltern was endeavoring to obtain replies to the Queen's message about the wounded by signalling with the electric light to the various vessels of the fleet. The weather was moderating, the wind was abating, and the sea going down. The conflagration in the town was still extending. Flames were rising from many quarters. Arabi, before leaving with his troops, had opened the prisons, and the convicts, joined by the lower class of the town and by some of the Bedouins, who had been hovering around for some days, proceeded to sack the city and kill every Christian they could find. A hundred Europeans, many of them wounded, who had, when the riots broke out, gathered in the Anglo-Egyptian Bank, resisted desperately the attacks made upon it. Scores of wretched fugitives were cut down or beaten to death. Towards daylight the assailants of the bank drew off, and the party made their way to the shore, where they were received by the men-of-war boats. The European quarter was in flames, the great square had become a mass of smoking ruins, and all the public buildings were destroyed. Nothing European escaped the rage of the fanatics.

Before daylight the next morning a boat sent on shore found that Fort Mex and the batteries near were all evacuated, and at daylight the Admiral made signal to the fleet to abstain from firing, as the town was evacuated. Orders were sent to the Chiltern (telegraph ship) to shift her berth and come close in shore. Further reconnoissances discovered that all of the forts were deserted.

The Admiral, anxious as to the state of affairs prevailing along the canal, despatched the Decoy to Port Said on the evening of the 12th.

On the morning of the 13th Admiral Seymour, in the Invincible, the Penelope and Monarch following, steamed into the inner harbor,

and a party was landed to take possession of Ras-el-Tin. Another party spiked and destroyed nineteen guns which were in position. The Monarch opened fire upon another battery, which was soon destroyed. Sailors and marines went on shore to spike all the guns they could find. At 4.45 in the afternoon the Khedive arrived and proceeded to his palace, where a guard of 700 marines was placed for his protection and to occupy the peninsula.

Four hundred men were landed from the Monarch for the further protection of the city. In the evening a party of sailors landed with a Gatling gun and cleared some of the streets of Arabs who were setting fire to and pillaging the town.

The list of killed and wounded in the engagement with the batteries and forts of Alexandria, on the 11th July, is as follows:

Inflexible, killed, . .	1	Wounded, . .	2
Alexandra, " . .	1	" . .	3
Superb, " . .	1	" . .	1
Sultan, " . .	2	" . .	8
Invincible,		" . .	6
Penelope,		" . .	8
Total killed, .	5	Wounded, . .	28

Among the ships struck, the Sultan had one shot through her mainmast, another through her after-funnel, besides two or three which pierced her hull in the unarmored parts. The Superb bore several traces of the fight, her funnel being pierced and also a plate below her foremast glacis torn away. The Inflexible had one of her boats rendered useless and others badly damaged. She bore the whole brunt of the west end of Ras-el-Tin fort for three hours and a half till she silenced it. The Penelope was struck five times, one gun being disabled. The Invincible was struck several times, frequently near the water line. Six shots penetrated, her foreyard was struck and fore-royal braces shot away. The Monarch was not hit, probably owing to her ability to shift her ground. The Alexandra received slight damage to her hull and had three guns disabled. At first the rumor was to the effect that the guns in question had been damaged by the enemy's projectiles; subsequently it was reported by a correspondent that they had burst: neither statement is correct. These guns are of the muzzle-loading type and were made at Woolwich on the Fraser system. In the A tube of one of the 10-inch 18-ton guns

of the lower battery there was a transverse crack about three inches from the muzzle. In another of the same battery there was a slight dislodgment of the A tube. The latter is regarded as serviceable. One 25-ton gun in the upper battery had its A tube cracked transversely on the upper side, about half-way from the muzzle to the B coil. This gun was fired several times after this accident. It was proposed to drill a hole at the extremity of this crack to prevent its extension if the gun had to be fired again. There would doubtless be difficulty in tracing the extent of a crack in steel. It is said that all these guns were cracked across the A tubes about half-way from the muzzle to the trunnions, the 25-ton guns on the upper and the two 18-ton guns on the lower side. The Alexandra received about twenty-five shots in her hull. One shell entered at the stern, passed into the captain's cabin and there burst; shattering everything in the cabin. Another passed through the cabin and completely destroyed everything within it. Others passed through the funnel-casing, smashed up one of the quarters of a steam-launch, passed through the gun-room, and did other damage. In no case did a single shot penetrate the armor of any of the ships.

On the 14th the gates of the town were guarded by seamen and marines. The fires were not spreading and nearly all looting was stopped. A force from the United States vessels-of-war was landed to protect the consulate, and another from the German ships to guard their hospital. The fleet was strengthened by the arrival of the Minotaur. In the organization of the force on shore the following naval officers were put in charge of the different departments: Captain Hotham, of the Alexandra, chief of staff; Captain Kelley, of the Achilles, head of the transport service; Captain Fisher, of the Inflexible, chief of the naval brigade; Commander Lord Charles Beresford, commandant of police; and Mr. Staunton, paymaster of the Invincible, head of the commissariat.

During the 14th the sailors and marines were at work clearing the streets. The remaining defenses of Alexandria were destroyed and the ruined batteries thoroughly inspected by a strong force. One of the 12-ton guns in the Ras-el-Tin fort had fallen back on the gun's crew. This was probably the last gun that was fired from that battery. Some of the dead had been hastily buried by the Egyptians, but numbers of bodies were lying about in the batteries. No one was to be seen on shore, except the sailors and marines, and occasionally one or two looters towards the Minet-el-Bassal quarter, who were

observed now and then running across a street with a load of plunder. Armed parties were sent into the town to patrol the streets and protect property. As far as open acts were concerned, good order was restored that evening. During the operations, nine or ten men were taken red-handed in the work of incendiarism and shot in the streets. This produced the necessary effect.

On the morning of the 15th a strong force of sailors with four Gatling guns marched round and through the city and reinforced the posts at all the gates. This demonstration produced a strong effect upon the native population. At Fort Gabarie an officer reported that during the night Bedouins laden with booty approached the fort, shots were exchanged and they fled, leaving behind two dead and all their plunder. At the Rosetta Gate, the guard observed, about midnight, a party of Egyptian soldiers plundering. When challenged they fired a volley; the marines replied and killed four of the plunderers, the rest fled. At the other posts some thirty men had been arrested for plundering. These were afterwards flogged, in compliance with an order to the effect that all plunderers should be punished in this way, and all incendiaries shot. With these exceptions the city was reported as quiet. During the day numbers of Bedouins who had been in the town plundering, left the city, leaving their booty behind them.

Lord Charles Beresford continued the organization of a police force. Under his command were a strong force of marines and three hundred disarmed Egyptian soldiers. Large numbers of Arabs were made to engage in clearing away the ruins. Steam fire-engines were used in extinguishing the fires, dynamite being used to blow up houses and thus arrest the progress of the flames. The fires were by no means confined to the European quarter, though there the destruction was greatest; they were scattered throughout the city and were caused by plunderers. It was only in the Grand Square and its vicinity that the ruin was complete and thorough. All British sources testify to the excellent service rendered by the American force in checking the fire, and, indeed, in arresting it altogether at several points. Messrs. Ross & Co.'s stores again opened, and were soon surrounded by hundreds of Jewish refugees whom the Admiral arranged to feed there. This firm kept the fleet well supplied with provisions in spite of every difficulty. In fact, on the 14th they recommenced coaling the ships.

During the day it was learned that Arabi was entrenching at Kafr-el-Dowar.

On news being brought to Lord Beresford that some of the Egyptian stokers were getting up steam and preparing to remove some railway rolling stock, a party was despatched by him to the spot, arriving just in time to stop half a dozen engines on the point of starting with trains laden with coal and grain. A portion of the rails were removed and a culvert blown up to prevent any repetition of the attempt. In the evening, in consequence of the reports of an intended attack by Arabi, mines were sunk in front of the gates, the work being done in an ostentatious way, in order to ensure the fact coming to Arabi's knowledge.

Late in the night all the posts on the fortifications and especially at the gates were strongly reinforced, two fugitive Europeans having come in with a report authenticating the native rumor of Arabi's intention to make an attack. They stated that Arabi was but a short distance away with the army and a large number of irregulars. Every arrangement was made to ensure the defenders of the walls falling back simultaneously on the palace, which was commanded by the guns of the fleet, in case the Egyptians should force an entrance at any point.

On the morning of the 15th two officers, deserters from Arabi's army, arrived at Alexandria and reported that it was Arabi's intention to cut the fresh water canal supplying the town. In consequence of this rumor, orders were given for the filling of all tanks and cisterns.

A detachment of cavalry was sent to Fort Marabout, with orders from the Khedive to the commanding officer to surrender at once. On Friday the Egyptian flag had been hoisted over it; but on two ironclads being sent to the fort, it was hauled down and a white flag hoisted. The fort still remaining in the hands of the enemy, it was determined on Thursday that, unless it was surrendered, it should be bombarded on the following day. The cavalry found it evacuated, and brought word that the garrison had withdrawn in the night.

About noon, the Minotaur arrived and landed her contingent of marines and seamen.

During the day the native population streamed back into the city through the various gates, with loaded donkeys, carriages, and vehicles of all descriptions. Men, women and children carried white flags as a sign of their submission.

Captain Maude, of the Téméraire, made a reconnoissance to within half a mile of the enemy's outposts. He found Arabi's army strongly

posted, and apparently with the intention of fighting upon the ground it had taken up. At the time of the reconnoissance there were no signs of work upon entrenchments. The reported strength of Arabi's army at this time was 6000 infantry, 400 cavalry, 36 guns, one rocket and one Gatling battery, with a large body of irregulars.

In spite of the British patrols, fresh fires occasionally broke out. On the whole, the fires had abated by night, and the work of restoring order progressed rapidly.

On the morning of the 16th the Tamar, with the marines, and the Agincourt, and the Northumberland, with the 38th Regiment and 3d Battalion 60th Rifles, arrived. The force now was sufficient not only to defend Alexandria, but to take the offensive, if deemed advisable. From the 12th to the 16th July 370 men had held two miles of lines against an army of some 9000 men, with a mob of ruffians behind in the city.

OFFICIAL REPORT OF BOMBARDMENT OF ALEXANDRIA.

By Admiral Sir Beauchamp Seymour.

In a dispatch of 20th of July, written on board the Invincible, Sir Beauchamp Seymour sent a detailed account of the action on the 11th between his squadron and the forts:

"As will be seen by the inclosed order of battle, a copy of which was supplied to each captain, I had decided to make two attacks; one by the Sultan, Superb, and Alexandra, on the northern face of Ras-el-Tin, supported by the fire from the after-turret of the Inflexible, anchored off the entrance of the Corvette Pass, thus enfilading the Lighthouse batteries; the other by the Invincible, Monarch, and Penelope from inside the reefs, aided by the fire of the Inflexible's foremost turret, and the Téméraire, which took up a position close to the fairway buoy of the Boghaz or principal pass leading into Alexandria harbor. The Helicon and Condor were detailed for duty as repeating ships, and the Beacon, Bittern, Cygnet, and Decoy were employed as directed by signal during the day.

"At 7 A. M. on the 11th, I signalled from the Invincible to the Alexandra to fire a shell into the recently-armed earthworks, termed the Hospital battery, and followed this by a general signal to the

fleet, 'Attack the enemy's batteries,' when immediate action ensued between all the ships in the positions assigned to them, and the whole of the forts commanding the entrance to the harbor of Alexandria. A steady fire was maintained on all sides until 10.30 A. M., when the Sultan, Superb, and Alexandra, which had been hitherto under weigh, anchored off the Lighthouse fort, and by their well-directed fire, assisted by that of the Inflexible, which weighed and joined them at 12.30 P. M., succeeded in silencing most of the guns in the forts on Ras-el-Tin; still some heavy guns in Fort Ada kept up a desultory fire. About 1.30 P. M. a shell from the Superb, whose practice in the afternoon was very good, blew up the magazine and caused the immediate retreat of the remaining garrison. These ships then directed their attention to Fort Pharos, which was silenced with the assistance of the Téméraire, who joined them at 2.30, when a shot from the Inflexible dismounted one of the heavy guns. The Hospital battery was well fought throughout, and although silenced for a time by a shell from the Inflexible, it was not until 5 P. M. that the artillery-men were compelled to retire from their guns by the fire of the Inflexible and offshore squadron. The Invincible, with my flag, supported by the Penelope, both ships being at anchor, the latter on one occasion shifting berth, and assisted by the Monarch, under weigh inside the reefs, as well as by the Inflexible and Téméraire in the Boghaz and Corvette channels, succeeded, after an engagement of some hours, in silencing and partially destroying the batteries and lines of Mex. Fort Mars-el-Kanat was destroyed by the explosion of the magazine after half an hour's action with the Monarch. About 2 P. M., seeing that the gunners of the lower western battery of Mex had abandoned their guns, and that the sappers had probably retired to the citadel, I called in the gun-vessels and gunboats, and, under cover of their fire, landed a party of twelve volunteers under the command of Lieutenant B. R. Bradford, of the Invincible, accompanied by Lieutenant Richard Poore, of that ship, Lieutenant the Hon. Hedworth Lambton (my flag-lieutenant), Major Tulloch, Welsh Regiment, attached to my staff, and Mr. Hardy, midshipman, in charge of the boat, who got on shore through the surf, and destroyed, with charges of gun-cotton, two 10-inch muzzle-loading rifled guns, and spiked six smooth-bore guns in the right hand water battery at Mex, and re-embarked without a casualty beyond the loss of one of their boats (Bittern's dingy) on the rocks. This was a hazardous operation very well carried out. Previous to this, after the action had become

general, Commander Lord Charles Beresford, of the Condor, stationed as repeating ship, seeing the accuracy with which two 10-inch rifled guns in Fort Marabout were playing upon the ships engaged off Fort Mex, steamed up to within range of his 7-inch 90-cwt. gun, and by his excellent practice soon drew off the fire. I then ordered him to be supported by the Beacon, Bittern, Cygnet, and Decoy, the Cygnet having been engaged with the Ras-el-Tin forts during the early part of day. I am happy to say, during the action, no casualties happened to those vessels, owing in a great measure to the able manner in which they were manœuvred, and their light draft enabling them to take up their position on the weakest point of the batteries. The action generally terminated successfully at 5.30 P. M., when the ships anchored for the night.

"The force opposed to us would have been more formidable had every gun mounted on the line of works been brought into action, but in the Ras-el-Tin batteries few of the large smoothbores, and fewer of the French 36-pounders, bought in the time of Mehemet Ali, were manned, the Egyptians preferring to use the English 10-inch, 9-inch, 8-inch and smaller muzzle-loading rifled guns. These guns are precisely the same as those which Her Majesty's ships carry, and no better muzzle-loading guns could be found. They were abundantly, even lavishly, supplied with projectiles of the latest description, chilled shot; and the sighting of the guns was excellent. The same may be said of the guns in the Mex lines, excepting that in them the 36-pounders were more used, and that one, if not two, 15-inch smoothbores were brought into action, in addition to the 10-inch, 9-inch and smaller muzzle-loading rifled guns fired. Fort Marabout brought two 10-inch muzzle-loading rifled guns into action at long range, shell after shell of which came up towards the inshore squadron in an excellent line, falling from ten to thirty yards short. Not one shell from the guns in the southern batteries burst on board Her Majesty's ships during the day.

"I forward for their lordships' perusal the official report of Captain Walter J. Hunt-Grubbe, C. B., A. D. C., of the Sultan, who most ably commanded the outside squadron, which bore the brunt of the action, as the accompanying statements of the damages sustained by the Sultan, Superb and Alexandra fully testify. I have no account of the damage sustained by the Penelope, as that vessel was shortly afterwards detached from my flag. The upper works of the Invincible and Inflexible were a good deal knocked about, but no serious

injury was done. No damage was inflicted on board the Téméraire or Monarch.

"I cannot speak too highly of the support I received from all the officers in command of the ships on this occasion. To Captain Walter J. Hunt-Grubbe, C. B., A. D. C., who commanded the northern division, my special thanks are due, and I would bring his name prominently to their lordships' notice. I desire also to thank Captains Thomas L. H. Ward, of the Superb, and Charles F. Hotham, of the Alexandra, attached to his division; Captains Henry F. Nicholson, of the Téméraire, and John A. Fisher, of the Inflexible (who were employed outside the reefs in support of the inshore division, and afterwards in aid of the northern attack); Captains Henry Fairfax, C. B., A. D. C., of the Monarch; St. George C. D'Arcy Irvine, of the Penelope; and Robert H. More Molyneux, of the Invincible, for the way in which they performed their several duties.

"Commanders George W. Hand, the senior of his rank engaged, of the Beacon; Lord Charles Beresford, of the Condor; Thomas S. Brand, of the Bittern; Lieutenant Hugh C. D. Ryder, commanding the Cygnet, an officer of over fifteen years' standing; and Lieutenant Arthur H. Boldero, commanding the Decoy, are all officers well deserving of advancement. The duties which have fallen on them before and since the action have been unusually severe, as all the communication between the ships outside and inside the reefs has been carried on by them, frequently in bad weather and at night, when the state of the bar has required most careful handling of their ships and an accurate knowledge of pilotage. I would also mention the name of Lieutenant William L. Morrison, of the Helicon, who, while repeating signals from me, was more than once under fire of the northern batteries, in a ship not constructed for warlike purposes.

"To the officers and men of the fleet generally I am much indebted for the speedy and successful issue of the engagement. Captain Hotham, of the Alexandra, has specially brought to my notice a deed of valor performed by Mr. Israel Harding, the gunner of that ship, who probably saved many lives by lifting and placing in a tub of water a 10-inch shell with burning fuse, which had passed through the ship's side and lodged on the main deck. He has also drawn my attention to the praiseworthy behavior of Commander Allan Thomas, of the Alexandra, throughout the day. I trust that this officer, and Staff-Commander Hosken, of my proper flagship, who is most favorably reported on by Captain W. Hunt-Grubbe, will

not suffer from my enforced absence from her. The whole of the captains speak in the highest terms of the conduct of their officers and crew.

"It is quite impossible for me to account for the very small loss sustained by Her Majesty's ships on this occasion, considering the amount of shell and shot which struck them, and the injuries inflicted on the hulls of the Sultan, Superb, and Alexandra, and in a lesser degree on those of the Invincible, Penelope, and Inflexible; but I may here express my deep regret that Lieutenant Francis Jackson, and Mr. William Shannon, carpenter, of the Inflexible, should have fallen. The wounded, who when last heard of were doing well, were sent to Malta in the Humber.

"I enclose a nominal list of the volunteers who formed the landing party to spike the guns in Mex batteries together with the boat's crew.

"I have, etc.

"F. Beauchamp Seymour,

"*Admiral and Commander-in-Chief.*

"*To the* Secretary of the Admiralty."

"Nominal list of officers and men who landed from the Invincible on the 11th July, 1882, and spiked the guns at Mex Fort and destroyed three with gun-cotton: Barton R. Bradford, Gunnery Lieutenant; Richard Poore, Lieutenant; the Hon. Hedworth Lambton, Flag Lieutenant; Major Tulloch, Royal Welsh Regiment; James Cross, chief gunner's mate; George Jennings, gunner's mate; James Williams, leading seaman; Thomas Gleeson, able seaman; Thomas Hawkins, able seaman; William Fox, able seaman; William Edwards, able seaman; Henry Reardon, able seaman; John Stanley, able seaman; George Robinson, able seaman; William R. Scorer, able seaman; F. J. Harwood, able seaman.

"The officer and men, named below, manned the steam pinnace, and remained in the boat: Mr. Edward E. Hardy, midshipman; Robert Hewitt, coxswain of pinnace; Francis Odlum, able seaman; John W. Towlson, ordinary seaman; John E. Davis, ordinary seaman; George Gurney, ordinary seaman; John C. Western, engine-room artificer; G. T. Barton, stoker."

THE DEFENSES OF ALEXANDRIA AND THE DAMAGE RESULTING FROM THE BOMBARDMENT.

By Ensign Thomas D. Griffin, U. S. N.

The Defenses.

The city is defended by two forts, Napoleon and Kom-el-Dik, and by a line of wall and ditches, extending from the new port to the eastward and southward, and ending at Gabarie, in the southwest portion of the city.

Fort Napoleon is a high mound of earth, and commands the entrance from the south and west. It has a barbette battery of six S. B. 32-pdrs.

Fort Kom-el-Dik is built of soft stone, and is surrounded by a layer of earth, twenty-five feet thick. It has four faces on its southern and eastern sides, and is sufficiently high to command all the entrances to the city. Halfway from the bottom there is a vertical stone wall extending around the fort. The magazine is in the centre of the upper half of the fort and about twenty feet below the parapet. Around the lower half of the fort there are rooms for the garrison. The battery consists of twelve S. B. 32-pdrs. placed on top of the fort.

There are three bastions in the walls, and gates fitted with draw-bridges. The walls are built of soft stone, and vary in thickness from twenty to thirty feet, and from fifteen to twenty feet in height. The ditch is from twenty to forty feet wide and thirty feet deep. Beyond the walls are three redoubts, also a small fort with a barbette battery of S. B. 32-pdrs. Over the Rosetta Gate were four S. B. 32-pdrs., and a few similar guns on top of the walls near the gate.

The above-named fortifications were the defenses of the city from attacks by land before the bombardment.

After the bombardment, one thousand English sailors and marines landed and strengthened these works with thirteen Gatlings and twenty 9-pdrs. The crews of these pieces consisted of eighteen blue-jackets when supported by marines, and when alone, of twenty-five men. These crews were armed with cutlasses and revolvers ; each man was allowed sixty rounds of ammunition. The companies were armed with the Martini-Henri rifles.

Three rifled 9-pdrs. were placed on top of Fort Kom-el-Dik, and manned by fifty-six sailors and supported by a company of marines. Twelve shell and twelve shrapnel were provided for each gun. A cover was made for the men by putting sand-bags on each side of the guns.

A small party of men was stationed on Fort Napoleon for signal purposes.

At Ramleh Station two hundred and forty marines guarded the station and entrance to the city from Ramleh. Between this point and Rosetta Gate a company was stationed ready to reinforce either position. Rosetta Gate was defended by a battery of two Gatlings; one was placed in the road under the gate and the other above the gate. Three S. B. 32-pdrs., loaded with grape, were placed immediately over the gate. The parapet of the walls was strengthened with sand-bags. The drawbridge could be raised only half way. The earth bridge across the ditch was mined and ready to be blown up in case the enemy should attempt to enter the city. At this gate there is a second wall, which would have been a protection if the first wall had been taken. Along the walls, at exposed places, sand-bags were placed on top, with loopholes, and men were stationed to fire through them from a banquette behind the walls.

Moharram Bey Gate is at the foot of Fort Kom-el-Dik, and was protected by a crew of men and one Gatling.

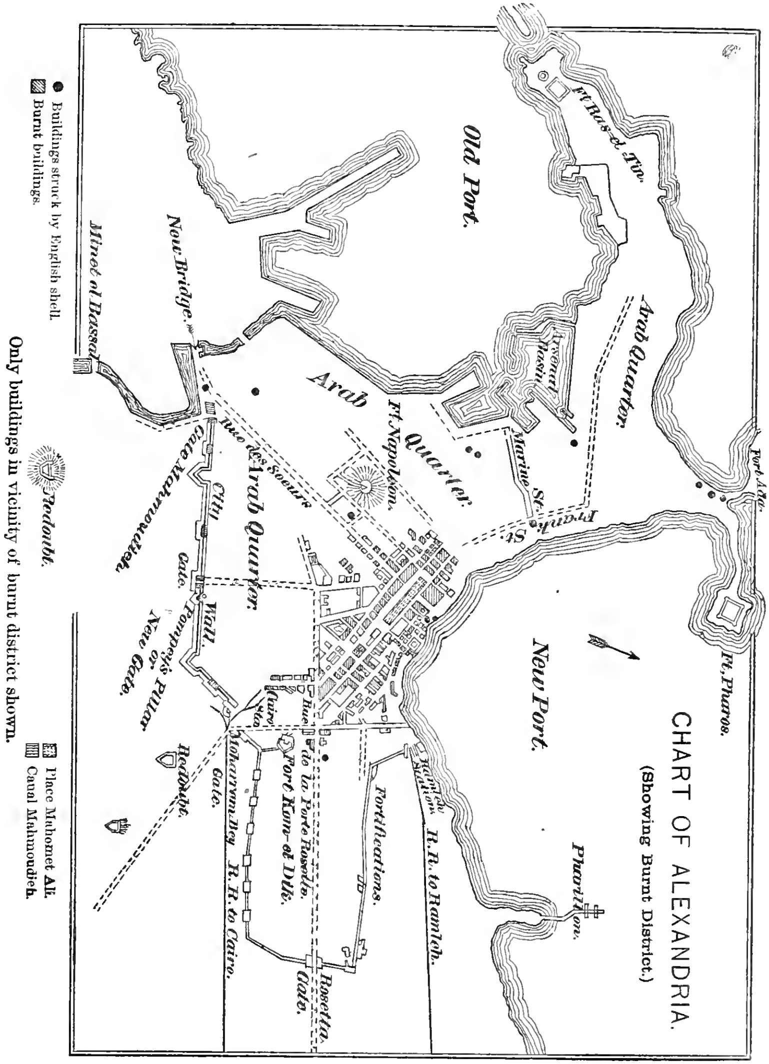
New Gate was barricaded with paving stones. A ditch was cut outside the gate, across the road, of the width and length of the drawbridge. Stones and logs of wood were placed over the gate to protect men stationed behind them.

Mahmoudieh Gate was defended by a Gatling. Near Pompey's Pillar there was a Gatling on top of the walls, manned by sailors.

Two Gatling guns, with crews of twenty-five men each, in charge of a lieutenant, were stationed near Gabarie Gate to command the New Bridge. Each gun was supplied with a thousand rounds of ammunition. The men wore cutlasses and revolvers.

The streets leading to Gabarie Gate were barricaded with paving stones, three feet long, eighteen inches thick and eighteen inches wide, with sand-bags on top. A few days after the city was taken, this position was reinforced by two hundred and forty marines. The street leading to the bridge across the canal was barricaded with iron plates, having three sides, about four feet high, and backed with paving stones. Stones were also placed on top, with loopholes

to fire through. These plates came from the cotton factory near the bridge. The bottom of the same street was barricaded by



placing rectangular wooden boxes across the street and filling them with earth. A narrow passage was left at each end of the street.

One hundred and fifty men patrolled the city, the Arsenal and

Tribunal being their headquarters. A few days after the English took possession of the city, armed parties of sailors from the ships of other nationalities were sent ashore to protect their consulates and to prevent burning and pillage.

The ships in the old port served to protect the city from attacks by Gabarie and the western gates, and also protected the engines which were run down on the new mole from the Gabarie Station.

The armored train served to annoy the enemy and keep him from approaching the city.

Fort Mex was manned, and a man-of-war stationed off the fort.

Men-of-war were kept close in shore between the city and Ramleh to guard that peninsula. As fast as troops arrived they were sent forward to Ramleh, where they took and fortified Waterworks Hill. Four 40-pdrs. were placed on the hill, and soon afterwards three 7-inch rifles were put in position on the side of the hill near the tower.

A canal was cut near Fort Mex, to allow the sea to fill up Lake Mareotis. These completed the defenses of the city, and would have left it open to attack only in the direction of Ramleh.

Damage to the City by Fire.

Sixty houses were burned, and, with a few exceptions, they were located in the European quarter of the city. They occupied an area of 107,364 square yards. All the houses on Mahomet Ali Square were burned, except St. Mark's building and the Tribunal. Between the Square and Rosetta street, and along the streets Cherif Pasha, Poste Italienne and Attarin, fourteen houses were burned and seven partly burned. The houses in the European quarter were built of soft limestone quarried near Fort Mex, and were from three to five stories high. They were the finest houses in the city, and were used chiefly as stores and hotels. The joists and rafters were wooden, and when they burned, the floors and walls fell and became a mass of dust. The houses in the Arab quarter were small and usually two stories high. There were about fourteen of them burned. The total loss by fire is estimated at fifteen millions of dollars.

Damage to the City by the Bombardment.

A mosque near the Arsenal was struck by a shell from an 80-ton gun which passed through the roof and side, leaving a hole ten feet long by five wide. The shell did not explode. A projectile passed

through the roof of a house on street of Mosque Ibrahim, through the side and through the walls of an adjacent house. Three or four houses near Fort Ada were struck and large holes made in their sides. A shell passed through one side of the Jewish Synagogue, leaving an opening about four feet square, tore up a portion of the pavement and struck the opposite wall without exploding. A large two-story building, used as a free school, had one corner of the house carried away by a shell. A shell passed through the Catholic Hospital walls without exploding. A projectile carried away a portion of the parapet on the Scotch School. A portion of a shell carried away about twelve feet square of a house on Rue des Sœurs. Several houses near the American Mission were struck by fragments of shell. A projectile carried away one-third of the roof of the new Catholic church. Near Gabarie bridge a shell passed through the side of a house, struck a buttress and passed out through the same side of the house. All of these houses, except two or three, can be repaired at a small cost. The total damage by the bombardment is estimated at a few thousand dollars.

THE RESULT OF THE BOMBARDMENT OF FORT MEX, ALEXANDRIA. PREPARATIONS FOR FLOODING LAKE MAREOTIS.

By Ensign Albert Gleaves, U. S. N.

Result of the Bombardment.

The Mex lines may be considered as composed of four separate batteries, viz. the fortified citadel, a lunette fortification SSE. of the barracks, a battery of two XV-inch S. B., mounted in an earthwork near the Winter Palace, and the Mex fort proper.

The battery SE. of the garrison was not in action at all on the 11th of July, and is intended as a defense from a land attack.

The XV-inch battery situated NE. of Fort Mex was in action part of the time and was not damaged.

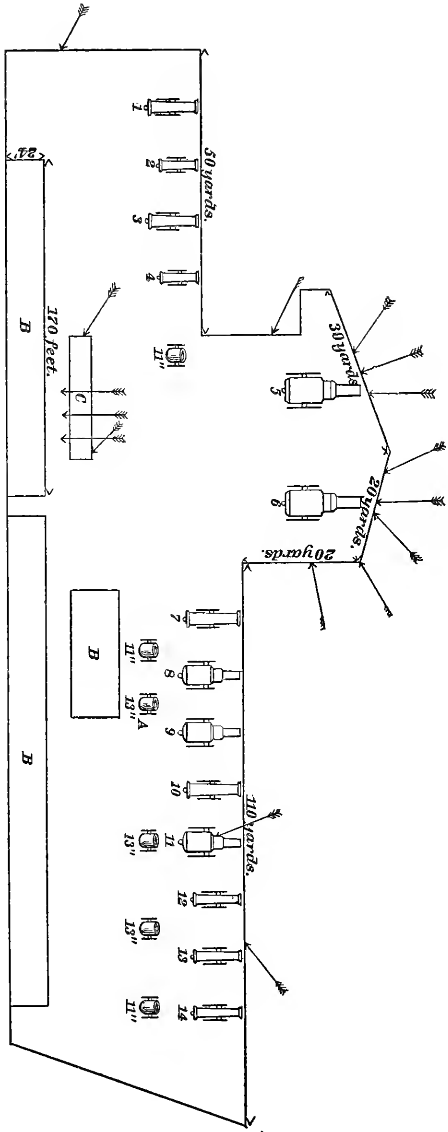
The Citadel is located several hundred yards from the sea, in rear of Fort Mex, and was provided with a small battery on its southwest face, consisting of five VI-inch old-fashioned smoothbores, mounted

on clumsy wooden carriages, and one 40-pdr. Armstrong casemated. During the bombardment two of these guns were dismounted, and a shell entering the casemate, exploded, killing the entire crew of the Armstrong gun.

In the Citadel were found eighty-seven large submarine mines, capable of holding two hundred and fifty pounds of gun-cotton each, large quantities of small shell, fuzed and loaded, and several hundred electro-contact torpedoes of peculiar construction. A great many of the latter had never been unpacked, and were found stowed in barrels just as they had been received. It is now known that the Egyptians had no wires, and this can be the only reason assignable for not planting the mines in the shoals and passes at the mouth of the harbor.

Besides these large supplies, twenty-five tons of gun-cotton and great quantities of powder were found in the village of Mex, and destroyed by the English. The submarine mines in the Citadel were also destroyed by blowing holes in them with disks of gun-cotton.

Fort Mex (the Old Canal Fort), an oblong fortification, is built upon rocks shelving into the sea, and is situated midway between the Marabout forts and the Kuhebé works, near the sea-end of the canal leading into Lake Mareotis, and commands the Corvette and Boghaz passes and the entrance of the harbor. In the long line of fortifications, extending from Fort Adjemi to Pharos, this was perhaps the strongest, and of the southern batteries it played the most conspicuous part, and was the most vigorously served during the recent bombardment. Its extreme length is about six hundred feet, by about seventy-five feet in width. Only the sea-face is armed, the flanks consisting only of low walls of soft stone. The crest line is broken near its centre by a salient; the extreme left is retired. Two of the heaviest guns were mounted in the salient, a battery of smooth-bores in the retired part, and the other guns distributed on the right, where by the natural conformation a line of fire was obtained directly over the crest of the rock. The advanced and retired parts are earth-works faced with sandstone. The thickness of the superior slope is thirty feet, and the command of the fort not less than thirty feet. A good line of retreat from the fort was the causeway across Lake Mareotis. The appended diagram shows the relative positions of the guns and mortars.



↠ Shows a few of the paths of projectiles on the parapet and at Magazine.

→ Struck sandstone facing.

B B B Shell rooms.

C Magazine.

The Diagram is not a scale drawing, and is only intended to show the position of the guns, &c.

Besides the regular armament, there were found in the fort one 10-inch M. L. R. Armstrong (1875) and one X-inch S. B., and just outside, eight 9-inch M. L. R. Armstrong, all unmounted, but a number of new gun-carriages in the fort suggests what would have been their disposition.

The shell-rooms, formerly used as barracks, formed the land side of the fort, and were abundantly supplied with appropriate ammunition for the smoothbores, and the battering, common shell, and solid shot, steel-pointed and studded, for the Armstrongs. Another shell-room inside the fort was also well stored with improved projectiles for the rifled guns.

During the bombardment, the Egyptian force at Fort Mex consisted of one captain, three lieutenants, one hundred and fifty sailors, under the command of an adjutant-major. The official reports state the following casualties in the fort: one lieutenant mortally wounded, fifty men killed, and forty-eight wounded.

The fort was attacked by the Invincible (flagship), Monarch, Penelope, Inflexible, and Téméraire, in the following positions: Inflexible, in Corvette Pass, 3700 yards N. by W. of Fort Mex; Téméraire in Central Pass, 3500 yards NNW.; Penelope, Invincible, Monarch, 1000 to 1300 yards W. by N. (official telegram to Foreign Office, 11th July). Afterward this force was increased by five small gunboats, working inshore of the large ships, and using their machine-guns with destructive effect from the tops.

The guns of Mex were served about five hours, until 1 P. M., when a landing was effected by a party from the fleet, seven guns were spiked and four destroyed by gun-cotton.

In considering the effects of the heavy cannonade on this fort it is noticeable that the fortification was injured very little; the damage it did sustain could have been easily repaired in a few hours. The English fire seems to have been concentrated especially on the rifled guns and with wonderful accuracy. The shell-houses were completely demolished, and the top of the magazine furrowed in three places by large shell, and its side struck twice, apparently by small shot, but it was not penetrated and consequently not exploded as has been erroneously reported.

The accompanying table is descriptive of the ordnance in the fort and the condition of each gun after the fight. The numbers in the first column refer to the numbers in the appended diagram.

Table showing Results of Bombardment on Guns in Fort Mex.

No.	Class of Gun.	Date.	Remarks.
1	X-in. S. B.	Unknown.	Not struck, spiked by landing party.
2	VI-in. S. B.	"	Dismounted. Gun and carriage on ground.
3	X-in. S. B.	"	Not struck, spiked by landing party.
4	VI-in. S. B.	"	Dismounted. Gun and carriage on ground.
5	9-in. M. L. R.	1870.	Total wreck. One shell exploded on parapet in front of gun; a piece of shell struck on right side of breech-coil forward; a glancing shot struck X-inch S. B. in rear of this, ploughing a deep furrow in breech-coil. Gun lying between slide, breech on bottom of carriage, muzzle on ground. This gun destroyed by gun-cotton. Charge placed in bore eighteen inches from muzzle and under cheeks of carriage, and fired by electric fuze. Blew three large pieces out of the right side of the chase and cracked *A* and *B* tubes in neighborhood of charge in all directions. Largest crack in *B* tube $\frac{3}{16}$ inch wide, 7½ inches long, at right angles to axis of bore. Right bracket shattered, on ground near gun; recoil-battens broken and twisted, and left bracket intact on ground twenty-five feet to the left in rear.
6	10-in. M. L. R.*	1870.	Total wreck. Struck on forward part of breech-coil, on left side underneath, and at shoulder of breech-coil on same side. Gun bore marks of Nordenfeldt bullets, one grazing in a track 4½ inches long on breech-coil. Another struck at an angle on breech-coil and penetrated about ½ inch, ripping up the iron around point of impact. Gun destroyed by gun-cotton. Both brackets blown away on ground near gun; gun resting on top of slide on bottom bracket of carriage. Muzzle cracked laterally around chase about eighteen inches from face.
7	X-in. S. B.	Unknown.	Not struck.
8	8-in. M. L. R.	1867.	Not struck. Muzzle cracked laterally by gun-cotton, twenty inches from face.
9	8-in. M. L. R.	1867.	Not struck. Muzzle very badly cracked laterally by gun-cotton, nineteen inches from face. Bears marks of Nordenfeldt bullets. Spiked by landing party.

* Fitted with mechanical training gear.

Table showing Results of Bombardment—(*Continued.*)

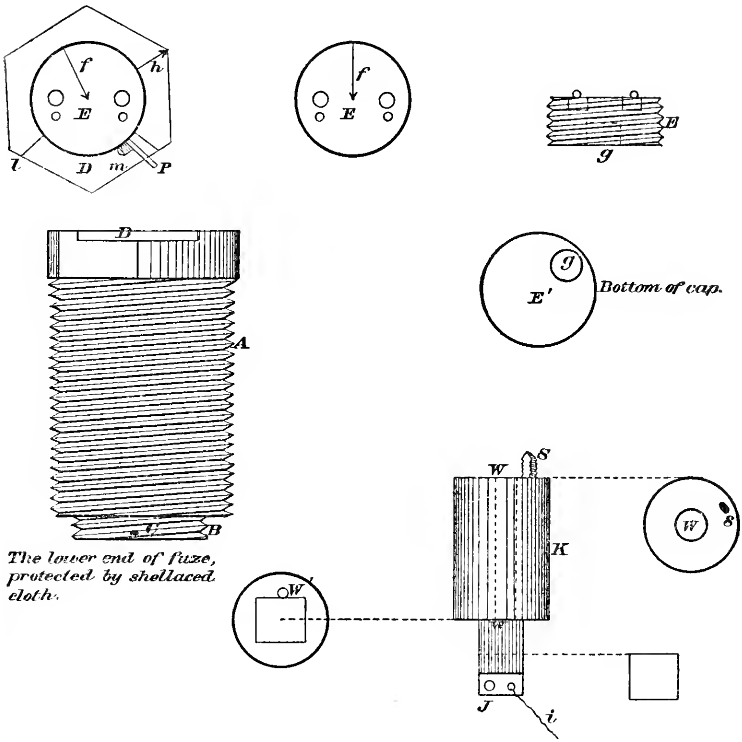
No.	Class of Gun.	Date.	Remarks.
10	X-in. S. B.	Unknown.	Not struck.
11	8-in. M. L. R.	1867.	Total wreck. Slide capsized on right side. Carriage intact on ground, upright; gun on ground at right angles to slide; struck on end of breech-coil to the left and underneath, tearing up a strip of the coil 24½ inches long, 4¾ inches wide, and starting the coil on the right side. *B* tube badly cracked; chase almost split off 33½ inches from face.
12	VI-in. S. B.	Unknown.	Dismounted. Apparently pulled down. Spiked.
13	"	"	Dismounted. Apparently pulled down. Spiked.
14	"	"	Dismounted. Apparently pulled down. Spiked.

Note.—All rifled guns are Armstrongs. The mortars were uninjured. *A* was struck by a small shot on the right o the breast-piece. Speaking of the excellent service of the Egyptian guns, Admiral Seymour says in his official report: "The same may be said of the guns in the Mex lines, excepting that in them the 36-pdrs. were more used, and that one, if not two, of the XV-inch smoothbores were brought into action, in addition to the 10-inch, 9-inch, and smaller M. L. R. guns fired."

The Boxer fuze used by the Egyptians is a wooden-stocked fuze graduated to 19 seconds. It is similar to the 3-inch B. L. H. fuze in use in the United States Navy, having two separate channels, one for the odd and the other for the even numbered seconds, and a main boring which contains the fuze composition. This fuze is purely a time one, with no percussion combination. A priming is wrapped around the head of the fuze, and the end passed through a hole and rests on the top of the composition. The priming is ignited by the flame of the discharge. When not in service this priming is protected by a strip of cloth, covered by a strip of thin copper, the whole enveloped in water-proof cloth. The top of the fuze is closed by a screw-cap, having a sharp spike projecting from its under side; the object of it seems to be to pierce the holes in the side of the fuze-stock.

The primers used were simply copper tubes filled with powder, pierced its entire length by a fine hole, and fired by the friction of a rough copper spur.

Percussion Fuze used by the Egyptians.



A. Brass adapter. *B*. Fuze stock (brass) with hexagonal head.

C. Wire to hold plunger (*K*), broken when gun is fired.

D. Portion on head of nut cut away to allow cap (*E*) to be fired by pin *P*.

E. Screw cap, fitted with priming composition in underside at *g*.

f. Arrow to be brought in coincidence with line *h* on nut.

g. Priming composition. When arrows coincide, *g* is immediately over the pricker *s*.

i. Wire made fast to plunger, end expended around end of fuze-stock.

j. Hole in plunger for wire *C*. *K*. Plunger with quick-burning composition *WW* ignited by fire from *g*. *S*, a jagged steel point. When projectile strikes, plunger flies forward and *S* pierces *g*.

o o. Holes in cap for wrench to turn cap or unscrew it.

P. Pin in cap, held in place by a lip, *m*. When arrows cannot be seen (at night) they are in coincidence when *P* takes against shoulder *l*.

Preparations for Flooding Lake Mareotis.

Lake Mareotis is divided into two basins by an artificial causeway thirty yards in width, leading from the Mex lines to the hills across the lake. The western or smaller basin is annually flooded through a canal, which is then dammed and the water allowed to evaporate, leaving a thick deposit of salt, the working of which is one of the native industries. At this season this basin is dry and the eastern basin nearly so, the ground, however, being quite firm enough for the transportation of artillery. Knowing that the Egyptians were constantly communicating with Alexandria by coming across the lake, and fearing an attack in force from this direction near Gabarie, situated between Mex and Ramleh, and where only a few troops were stationed, the English general gave orders to flood the eastern lake. The western lake, either dry or flooded, not offering any military advantage, and being the property of the Khédive, was not to be considered.

From the sea, near the southern end of Fort Mex, an irregular line of bastions extends nearly to the lake, which at that extremity is swept by a railroad embankment seven feet high, on a level with the causeway on which the track is continued. Through the centre of a moat at the foot of the bastions a cunette or ditch runs from the sea to the lake; where the line of fortifications ends there is a dam, and the cunette at that point makes a sharp curve to the northeast and is continued to the embankment, under which it passes to the lake through an arched opening.

The level of the lake is eleven feet three inches below the sea, and the cunette already furnishing the connecting canal, there were three things to be done before the water could be admitted: first, the cunette had to be cleared; second, a proper escape made at the lake end; and third, an opening made for the admission of the water at the sea end. As it was decided that the water must have a straight course from the dam, owing to the bend in the cunette at that point, the cunette was extended from the dam to the embankment in a straight line, and the blue-jackets detailed to build a wall along its side, to keep the water from overflowing the salt field. This wall, made of mud, was four feet high, ten feet thick, two hundred yards long, and faced with sandstone. An opening was cut through the embankment at an angle of 45°; this cut was very difficult, owing to the hardness of the soil, which softened, however, as the depth increased.

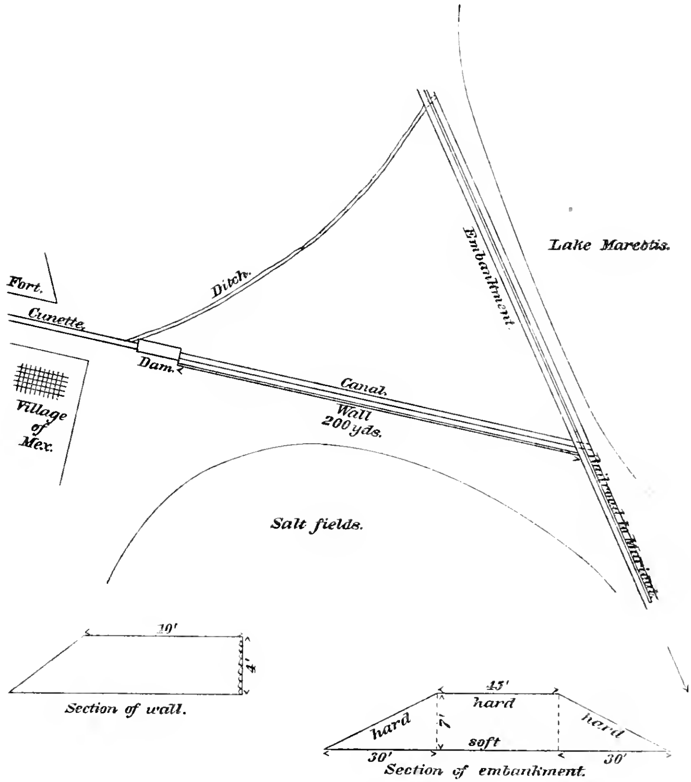


FIG. 1.

At the sea-end was the important and most difficult work. The idea was to excavate the cunette to a depth of four feet below the sea level, and this had to be commenced about five hundred feet from the sea. The first three hundred and fifty feet it was necessary to dig only eighteen inches; then for fifty feet to a depth of two feet; the next fifty feet was through four feet, and finally through nine feet, which was the deepest cut. In this part large rocks were found. The excavation thus made was thirty feet wide, and was continued within two feet of the sea.

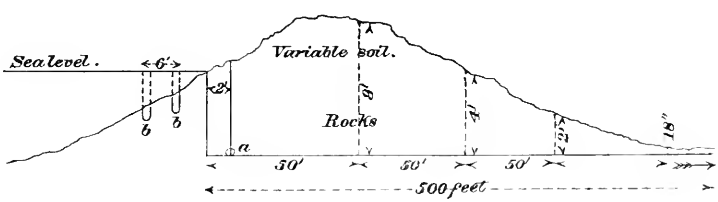


FIG. 2.

The dam was to be blown up by gun-cotton, and Fig. 3 shows how the charges were distributed.

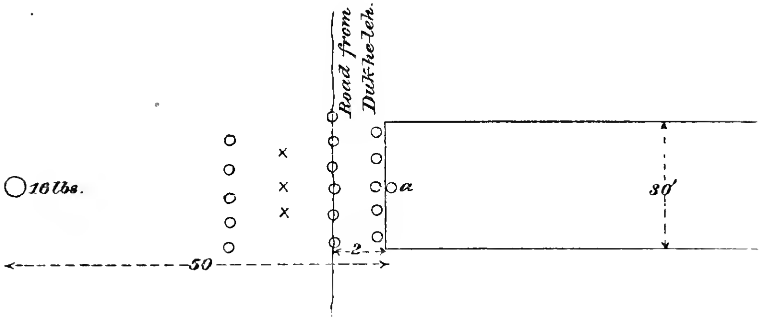
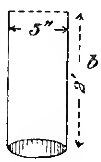


FIG. 3.

o represents 7½ lb. charges. x represents 5 lb. charges.
a same as *a* in Fig. 2. *b* same as *b* in Fig. 2.



Stove-pipe containing charge of gun-cotton. Sides very thin.

Holes were bored in the dam for the charges to a depth of two feet, and in the middle of the dam, on the inside on bottom, another charge was placed (*a*, Figs. 2 and 3). The first and second rows of charges in the sea were placed in the bottom of very thin stovepipe (two feet by five inches), and sunk in holes bored for them; the tops of the pipes were covered by rocks, to keep out the water. The third row was laid on the bottom; these rows were about six feet apart. Outside, fifty feet from the dam, a large charge of 16 lbs. gun-cotton was laid on the bottom in a depth of two and a half feet of water. When these arrangements were completed a wave washed over the dam, breaking a portion of it, and deranging the positions of several of the charges. The dam was repaired, and the charges changed somewhat as shown in Fig. 4.

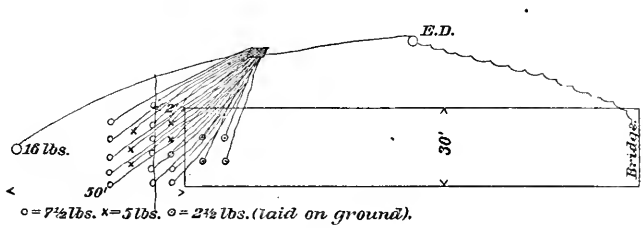


FIG. 4.

The Bickford fuze was used, and the following plan devised for the instantaneous ignition of the numerous fuzes: A shallow tin box, one inch deep and about eight inches square, was made, and the bottom pierced with about thirty holes; as many holes as were used were fitted with tubes projecting from the bottom, and through each tube the fuze from each charge was led, and the end frayed out inside the box. Another fuze was led from the box to an electric detonator some distance off, and the box then filled with gunpowder. The detonator was connected to a firing board on the bridge over the moat. The first trial was a failure, and examination revealed a fault in the electric detonator. This was corrected, and the firing key again pressed. The result was excellent; the entire dam was blown away, and the water rushed in at the calculated velocity of fifteen feet per second.

Trouble was now experienced at the other end of the canal. When the explosion took place a portion of the embankment inside the dam fell in, and more water was admitted than was expected. The wall built by the blue-jackets was not high enough, and the water, gradually rising in the canal, at last overflowed it; the wall gave way about the centre of its length, and the water poured into the salt-fields through a gap fifty feet wide. The stream was thus divided into three branches; one trickling through the old ditch into the lake, the other following its new course under the railroad embankment, and the third and largest flooding the salt-fields. After a great deal of hard labor the entrance to the canal was stopped by sinking a scow outside, floating a spar across it and filling it up with stones. Before the wall could be repaired Tel-el-Kebir fell, and a telegram was received not to flood the lake. The blue-jackets volunteered to finish this wall, and the dam was blocked up for a full day. The construction of this canal occupied 370 men nine days. The working force consisted of 15 sappers and miners (Royal

Engineers), 100 sailors, 230 Arabs, and 25 infantry. It cost the British government £500, nearly £450 of which was paid for Arab labor.

It is more than probable that the object of flooding the lake could not have been realized, for it was demonstrated that, considering the area of Lake Mareotis as 150 square miles, and the flow of water as 6,000,000 cubit feet per hour, the water would reach a depth of only one foot in one month, and this result assumes the bed of the lake to be perfectly level. Taking into account the depressions that do exist, the calculated depth would be reduced to two or three inches.

RESULTS OF THE BOMBARDMENT OF FORTS RAS-EL-TIN, ADA, AND PHAROS, ALEXANDRIA.

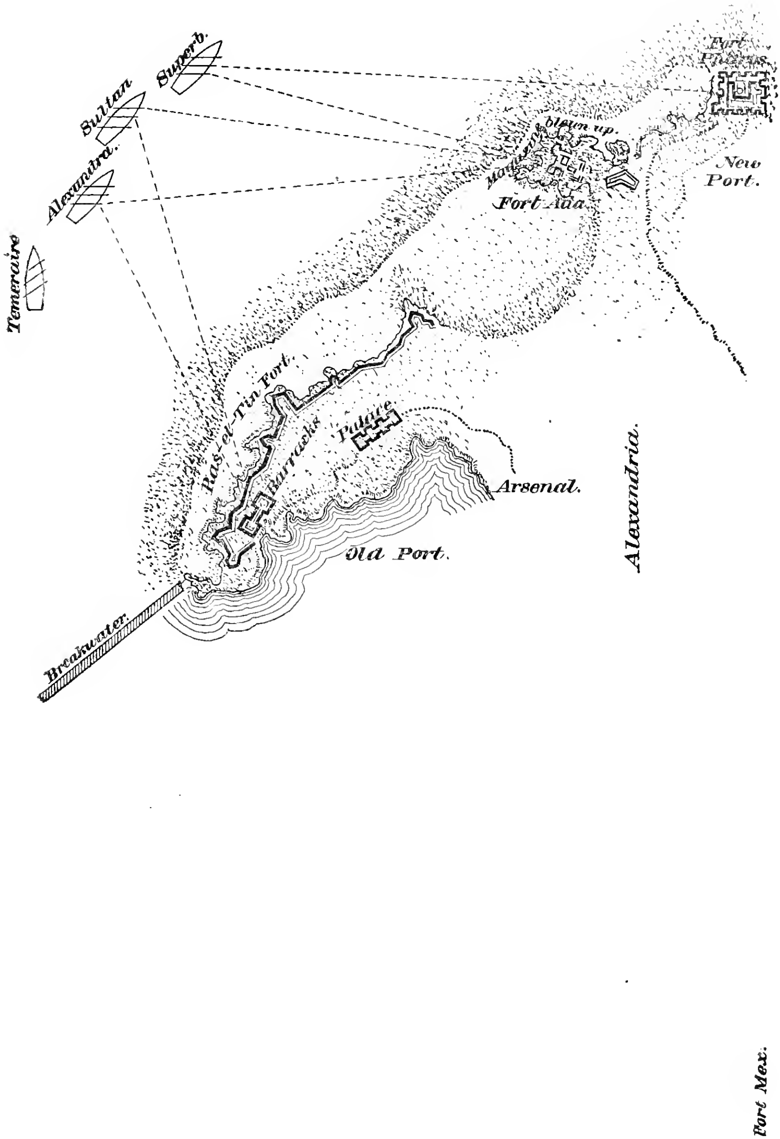
By Ensign Charles M. McCarteney, U. S. N.

Fort Ras-el-Tin.

This fort, commonly called the "lighthouse fort," is situated upon the extremity of a peninsula known as Eunostos Point, immediately to the westward of the city, and commands the approaches from the northward, northward and eastward, and westward, and the south side commands the inner harbor, or old port. It is essentially an earth or sand fortification, supported by a facing of limestone; while above, the parapets, embrasures for guns, shell-rooms and magazines, are constructed wholly of this stone. The thickness of the earthworks varies, probably reaching as much as twenty-five or thirty feet on the sides facing the sea.

Armament.—The batteries of this fort consist of one 10-inch M. L. R., four 9-inch M. L. R., two 8-inch M. L. R., one 7-inch M. L. R., all Armstrong guns; the 7-inch being mounted on the Moncrieff system. Also, six 13-inch mortars, five XV-inch S. B., three X-inch do., two IX-inch do., and twenty-two very old S. B., apparently VI-inch and 32-pdrs.

Damage.—Owing to the softness of the stone forming the upper portion of the works, embrasures, shell-rooms, magazines, &c., the fort was very badly damaged; for, on being struck by the projectiles,


Superb.
Sultan
Alexandra.
Temeraire
Fort Pharos.
blown up.
Magazine
Fort Ada.
New Port.
Ras-el-Tin Fort.
Palace
Barracks
Arsenal.
Old Port.
Alexandria.
Breakwater.
Fort Mex.

the stone would crumble away. The shell-room, which occupied a conspicuous position in rear and to the right of the lighthouse, was completely demolished; and this, with the magazine, seemed to have been the targets at which the English directed their fire. The latter, however, was not struck. The lighthouse was hit in several places, and it was thought at one time that it would fall, but the injury has since been repaired. The explosion, which killed many men, must have been that of a portion of the shell-room, which I found in ruins. The south side, facing the harbor, was not injured, as the guns on that side, being old, worthless smoothbores, were not fired, and consequently the fire of the ships was not directed against it. A portion of the Ras-el-Tin palace, adjoining the fort, was set on fire and destroyed by being struck with a shell.

The damage to the battery was as follows: one 9-inch Armstrong gun, by its own recoil, carried away the training bolt which confined it in the embrasure, drawing it out of the soft stone, and fell back on the rear end of the slide, elevating the forward part and rendering the gun completely useless. Another 9-inch gun in exactly the same condition, caused by a shell striking and carrying away the embrasure in which the gun was situated. A third 9-inch gun dismounted and carriage demolished by being struck with a shell, which tore off the outer hoop over the trunnions, knocked the gun over and buried two men beneath it. A fourth 9-inch gun rendered useless by having a projectile in the gun, *butt out*, evidently placed in that position during the excitement of the engagement. The garrison made repeated efforts to dislodge it, but being near the muzzle they were swept away at every attempt, and the gun silenced. One 8-inch gun knocked off the carriage and the latter demolished by a shell striking the embrasure and exploding. The 9-inch gun mounted on the Moncrieff carriage was uninjured, and apparently but little used, if at all. Thus it will be seen that the four 9-inch guns and one of the 8-inch guns were rendered useless, and the 10-inch gun showed cracks running around the chase near the muzzle, the result of the repeated firing, these cracks being a marked feature in all the Armstrong guns used.

Fort Ada.

This fort, the smallest of the three, is situated about N. by W. from the city, on a neck of land running to the north, and commands the approaches from the northward and westward. In general construction it is the same as the one previously described, the thick-

ness of the earthworks being over thirty feet, but has less stone-work above.

Armament. — Three 9-inch, one 10-inch, one 8-inch Armstrong rifles, three 13-inch mortars, and thirteen X-inch S. B.

Damage.—This fort was destroyed and the guns silenced early in the action by the explosion of the magazine, which occurred about three hours after the bombardment commenced, killing the garrison, and stopping further resistance. The shell-house, in the rear of the fort, was also struck in several places, but not as badly injured as that at Ras-el-Tin. The damage to the battery is as follows: The 10-inch rifle apparently had a premature explosion, the projectile bursting near the muzzle. The lands of the rifling were badly cut up, and there were deep scores in the grooves between. A deep, heavy crack or cut ran longitudinally on the under side, and a number were found on the chase, running transversely. Two X-inch S. B. were struck and dismounted, and the carriages both smashed. The three 9-inch rifles and the 8-inch were all in good condition, as they were but little used. A large quantity of projectiles, many of which were broken, was found here, but the evidence was that they were stored in the magazine which exploded, as they were all found immediately in rear of it. Several projectiles were found imbedded in the sand at this fort, and were in good condition, having failed to explode from the lack of resistance opposed to them. One large 80-ton gun battering shell, from the Inflexible, was found, unexploded, upon the parapet, and *pointing seawards.* In conversation with the gunnery lieutenant of the Invincible, I learned that many projectiles were found thus, the theory being that, towards the end of their trajectory, having almost lost their velocity, they turned over and fell so—on the boomerang principle.

Fort Pharos.

This fort is situated on the northeast end of a narrow strip projecting from the neck on which Ada is situated, and due north of the city. It is quadrangular in form, and commands the approaches from all sides, and particularly the new port. It is supposed to stand on the site of the old Pharos lighthouse. It is built entirely of solid masonry below, with casemates on all sides seawards, and earth parapets above. It has a citadel, and this, with the embrasures, shell-rooms, &c., are constructed of the same soft stone as in the previous cases. It is, however, the strongest of the three, maintained the

most stubborn resistance, and was the last to be silenced, its defense ceasing about ten hours after the bombardment commenced, when it received the combined fire of the Inflexible, Téméraire, Alexandra, Sultan and Superb.

Armament.—One 10-inch, three 9-inch, two 8-inch Armstrong rifles. Smoothbores, four VIII-inch, fourteen VI-inch and 32-pdrs., and six 13-inch mortars on parapets, and twenty-five or thirty VI-inch and 32-pdrs. in casemates — all these latter useless as far as resistance was concerned, and, therefore, not used. From the position of two of the 9-inch guns facing the eastward they could not have been brought to bear, and their condition verified this supposition, thus reducing the effective armament of this fort one-third.

Damage.—The shell-room was struck by a shell which exploded (apparently 10-inch), and this, I believe, was the cause of the final silencing of the fort. A great many men were killed, and their bodies buried in the casemates. The citadel was repeatedly struck, and much injury must have befallen the garrison from the clouds of falling masonry. The embrasure containing the 10-inch gun was struck by a 12-inch battering shell, which did not explode, but carried away the stone-work, which, falling inside, rendered the gun useless, as it could not be manned or trained. In all the guns cracks were visible, running transversely around the chase; no other part of these guns seems to have been injured or suffered from the fire. Two X-inch S. B. were struck by shells which fell inside the fort, and the guns dismounted and carriages smashed. One small VI-inch gun was struck by a projectile, and the gun thrown over the parapet and through the roof of the casemate below, the carriage being shattered.

The fuze used by the English, as far as I could learn from persistent inquiries, was "the general service percussion fuze." From various sources I find that a very small percentage of the shells exploded, probably not as many as one-fourth—especially those which struck the earth and sand—and of those which did explode, the fragments were few and large, frequently breaking in not more than two or three pieces, generally in two halves transversely. All that were uninjured were removed.

The defense seems to have been wholly made with the Armstrong rifles, as none of the smoothbores, not even the XV-inch, which were in good position, appear to have been used. Thus the total number

of effective guns in these three forts was eighteen, and of these, two or three could not be brought to bear.

The supply of ammunition seems to have been very abundant, and large quantities of Palliser and smoothbore projectiles, canister, &c., were on hand after the bombardment. Small auxiliary magazines, built under the embrasures and situated beside the guns, were filled, making the supply very convenient and accessible, so that evidently the destruction of the guns themselves caused the fort to be silenced.

The great fault in the construction of the magazines and shell-rooms was the conspicuous positions they occupied, which caused them to be greatly exposed, and to have the fire concentrated upon them. This defect caused the explosion in Fort Ada and the silencing of that fort. In Fort Pharos the shell-room was exploded, and in the Ras-el-Tin the shell-room was almost totally destroyed.

The Nordenfeldt guns, I am told, caused great destruction among the men, sweeping away whole gun's crews at a time, and in the Ras-el-Tin effectually prevented the dislodgment of the projectile which was placed in the 9-inch gun butt out, previously mentioned. The attacking ships, starting from a range of from 3000 to 5000 yards, finally closed in to 800 yards, thus giving an excellent opportunity to develop the usefulness of these very effective modern additions to the armament of our vessels.

These three forts were attacked by the following ships: Inflexible, four 80-ton guns; Alexandra, two 25-ton guns, ten 18-ton guns; Sultan, eight 18-ton guns, four 12-ton guns; Superb, sixteen 18-ton guns; Téméraire, four 25-ton guns, four 18-ton guns. The last-named vessel did not add the weight of her metal until towards the end of the engagement, and the Inflexible worked between Fort Mex and the three I have described.

On the whole, the result is most interesting as showing the effect of modern ironclads and their heavy ordnance against fortifications on shore, and proves that thick earthworks are the best resisting medium. The accompanying plan shows the position of the forts and of the attacking vessels.

THE NAVY AND MARINES ON SHORE.

The following despatch from Major-General Sir Evelyn Wood, dated from Ramleh, the 20th September, 1882, was forwarded by General Sir Garnet Wolseley to the Secretary of State for War, and was by him communicated to the Admiralty:

"*Sir*:—I have the honor to request that you will be good enough to bring to the notice of the commander-in-chief in Egypt the excellent work performed on shore by the officers and men of the Royal Navy and Royal Marines during the period I have been in command at Alexandria. All requests from me for their employment on shore have been met with the utmost alacrity and good feeling by Admiral Dowell, C. B. The work performed by the several parties has been of an arduous and varied nature, but I particularize the following: Commander Hammett, R. N., with a party of blue-jackets from the Minotaur, landed on the nights of the 31st August and the 1st September, and demolished by gun-cotton a house, near our advanced posts on the canal, which afforded cover to the enemy. Commander Morrison, R. N., was relieved shortly after my assuming command by Commander Parr, R. N., whose men, under the direction of Lieutenant Scott, R. N., worked in a most praiseworthy and successful manner in mounting three 7-in. M. L. R. guns on the water tower position. The sand being very heavy rendered the work most difficult. These guns were effectively used against the enemy's earthworks, under the direction of Commander Parr and Lieutenant Wrey, R. N. It is right that I should add that Major-General Sir A. Alison had, previous to his departure, spoken to me of Lieutenant Scott's work in the highest terms of praise. We derived great assistance from a party of blue-jackets under Commander Henderson, who, with the 21st company Royal Engineers, all being under the command of Captain Pusey, R. E., repaired the rail between Kafr-el-Dowar and Alexandria. The destruction of a heavy piece of masonry thrown up across the line demanded great exertion. The cutting of the Mex dam was an arduous piece of work performed by Lieutenant Scott, R. N., and a party of blue-jackets. They also built a retaining wall measuring 170 yards long, 12 feet broad at the top and 15 feet broad at the bottom. Good service was done by the Royal Marines while in garrison at Alexandria, under the command of Major French, R. M. A. "I have, etc.,

"EVELYN WOOD,

"*Major-General Commanding at Alexandria.*"

The following is a brief *résumé* of the operations of the marines, furnished by one of the officers of the battalion:

"On the 17th July a battalion of five companies (strength 591 of all ranks) under the command of Lieutenant-Colonel Ley, landed at Alexandria and occupied part of the lines of defence of that place, under Sir Archibald Alison's orders. On the 5th August the battalion, under the command of the late Major Strong, formed part of the right column of attack in the reconnoissance in force, under Sir A. Alison, in which the casualties were, as far as the marines were concerned, one private killed and eleven wounded, two of the latter subsequently dying of their wounds. On the 8th of August Colonel H. S. Jones, of the Royal Marines, arrived in the steamship Decca with 450 men. Colonel Jones landed at Alexandria and assumed the command, sending on the reinforcements under Lieutenant-Colonel Graham, Royal Marines, to Port Said, there to await orders. On the 19th August the battalion, under Colonel H. S. Jones, embarked in the steamship Rhosiana as part of the 1st Division of the Army Corps, and proceeded through the Suez Canal to Ismailia. The next day two companies, under the command of Major J. W. Scott, R. M., landed at daybreak and occupied Port Said in conjunction with the navy, under the command of Captain Fairfax, of the Monarch. On the same day Lieutenant-Colonel Graham and three companies of Royal Marines landed and took possession of Ismailia in conjunction with the navy under Captain Fitzroy, of the Orion. On the 21st August the battalion under Colonel Howard S. Jones disembarked at Ismailia and were shortly afterwards joined by the companies under the command of Lieutenant-Colonel Graham and Major Scott, thus completing his battalion to upwards of 1000 men. The marines were posted to the first, or Guards Brigade, under the Duke of Connaught. Two days later, by the express desire of Sir Garnet Wolseley, one company, under Captain Heathcote, was detached as his personal escort during the campaign. On the following day the battalion made a forced march from Ismailia during the night to reinforce the troops engaged that day at El Magfia. The force was joined on the 25th, and proceeded to follow up Arabi's army, driving him from his stronghold at Tel-el-Mahuta. That evening, with General Graham, V. C., the force marched to Mahsameh and occupied the enemy's camp, which had that morning been captured by cavalry. There they remained some days. On the 28th the force marched from Mahsameh to the relief of the garrison of Kassassin, which had

been attacked by 10,000 Egyptians. The battalion came into action at 7 o'clock in the evening, and in conjunction with the garrison drove the Egyptians back, inflicting great loss on the enemy. From this date the battalion was attached to the 2d Brigade under General Graham, V. C. It was on the 9th September when the Egyptian army made an attack on the camp at Kassassin, with a force numbering 15,000 of all arms, in addition to some 5000 Bedouins. The battalion took an important part in the action, being in the fighting line, and were fortunate in capturing two of the enemy's guns, which were taken in dashing style by the companies under the command of the late Captain Wardell and Captain Coffin. In this engagement the battalion had twenty-seven non-commissioned officers and men wounded, several of whom died shortly afterwards.

"On the 12th September, the greater part of the army at Kassassin struck tents at sunset, and commenced their celebrated night march across the desert, which was to bring them before the lines of Tel-el-Kebir. The battalion of Royal Marines was again fortunate in being placed in the front line, and formed the left battalion of the brigade of General Graham, V. C. The march across the desert was conducted in silence, the force occasionally halting to rest. At dawn on the 13th of September this brigade joined the second brigade 1000 yards from the enemy's earthworks, and before it had time to get into fighting formation the enemy opened a heavy fire, which increased in rapidity as the brigade advanced. The advance of the Royal Marine fighting line was the admiration of their brigadier and all who witnessed it. Not a shot was fired by them until within 150 yards of the intrenchments. Then the fire being so terrific, the colonel commanding ordered them to halt, fix bayonets and open fire, as the fighting line crept up towards the trenches. They were reinforced by the supports and reserve respectively, and when within thirty yards of the ditch they gave a wild cheer and dashed into the trenches. Soon the parapet was carried, and on gaining the inside of the intrenchments the battalion did good work in clearing the defenders from the trenches on the left, and from the battery which was being enfiladed by a portion of the Highland brigade. In this action the battalion lost in killed and wounded two officers, one sergeant, and ten privates killed; four officers, two sergeants, two buglers, and forty-two privates wounded—four subsequently dying of wounds—and two privates missing. After the battle of Tel-el-Kebir, the Royal Marines were among the first regiments sent to garrison

Cairo, and on the entry of His Highness the Khedive into the city, lined the streets with other corps to receive him, and formed part of the army corps which was reviewed by the General Commanding-in-Chief in the presence of the Khedive, in the Place d'Abdin, Cairo, on the 30th September. After remaining in camp at Cairo for about three weeks, the battalion received orders to proceed to Alexandria to embark in the steamship City of Paris, *en route* for England."

Another account says:

"The Marine Light Infantry were ordered to march from Kassassin camp at sunset, 12th inst., and formed the left of the second brigade, 1st division, under Major-General Graham, V. C., C. S. I., the remainder of the 1st division (Guards Brigade) being in our rear in reserve. On the left were the Highland Brigade, with the 2d brigade, 2d division in reserve; the artillery between the two divisions, 1000 yards in rear. The Royal Marine Artillery, now attached to the corps artillery, formed Sir Garnet Wolseley's body-guard. By the programme sketched out by the commander-in-chief, the two leading brigades were to march in line upon the intrenchments, attack before daylight, and carry them without firing a shot. After a march of ten miles through the desert they found themselves, just as dawn was breaking, about 1200 yards in front of the northern portion of the Tel-el-Kebir lines; but the brigade, owing to the stars being occasionally obscured, lost its true direction and had to make a change of front. Whilst this was being done the enemy opened fire, and by the time the brigade had formed into line a very continuous fire of shot and shell was being poured into it. As soon as the brigade movement was completed, Colonel Jones at once formed the marines for 'attack,' by sending out three companies on the fighting line, three in support and two in reserve. As the extended line approached the position, which was entirely devoid of cover, the fire increased in intensity, but the men pressed steadily forward up the slope of the glacis, reserving their fire until within 100 or 150 yards of the ditch, then fixing bayonets, the fighting line being reinforced by the supports, worked by rushes, in spite of a terrific fire, up to the top of the glacis, when, being again reinforced by reserves under Lieutenant-Colonel Graham, R. M., the whole rushed forward with a loud cheer, dashed into the ditch and scrambling up the parapet from seven to nine feet high, engaged the enemy in a sharp hand-to-hand fight. This lasted but a short time. The enemy, being overpowered, broke

and fled in all directions. The marines followed them up for a distance of about four miles, clearing position after position, until they came to Arabi's headquarters camp at Tel-el-Kebir. This they found standing, but evacuated, it having been left in haste, as everything appeared in order. Here they were ordered to halt and occupy some of the deserted tents. Arabi is supposed to have had 25,000 troops of all arms occupying this position when it was attacked. Sixty-six guns were captured, together with large quantities of stores, ammunition and railway rolling stock, besides a large number of prisoners. The casualties in the marine battalion were very severe, amongst them Major Strong, who was shot through the heart while most gallantly leading his fighting line up the glacis, within twenty yards of the enemy. Captain Wardell, one of the most valuable and efficient officers in the battalion, was also killed, being shot through the head, close in front of the parapet while cheering on his men. In addition to the above, one non-commissioned officer and ten men were killed; four officers and forty-three non-commissioned officers, buglers, and privates wounded, one since dead. Sir G. Wolseley specially thanked the officers and men of the battalion for the splendid manner in which they did their work that day, and for the great assistance they had been to him throughout the campaign. General Willis, commanding 1st division, and General Graham, commanding 2d brigade, also congratulated the battalion on its success and great steadiness under fire."

MOUNTING OF GUNS AT RAMLEH.

General Hawley requiring some heavy guns mounted, Lieutenant Percy Scott, gunnery lieutenant of the Inconstant, procured three 7-inch 7-ton guns from one of the Ras-el-Tin batteries. These guns had first to be dug out of the débris in which they had been buried by the explosion of the magazine in their rear. With materials procured from other forts, extemporary contrivances were erected for dismounting and transporting the guns, which were skidded, with their carriages, slides and gear, over the sand. Great difficulties were encountered at the metal road and thence to the station, and by train to Ramleh. Here the sand was not found sufficiently solid to admit of the proper adjustment of the slides, as the pivoting bolts had no hold. Lieutenant Scott, by way of resource, buried a 32-pdr., muzzle

upwards, at the fore-end of the slide, the bore taking the pivoting bolt. In another case he buried two common shell of the Inflexible, picked up in the town. To these a cable was shackled, then brought up on each side of the gun to the fore-end of the slide, thus securing it against recoil. Another gun was mounted on the top of a hill in an ingenious way. Several hawsers were spliced together so as to make one long hawser; it was then rove through a leading block (anchored firmly in the sand by means of sleepers), one end being taken to the sling wagon and the other to two engines on the line, which, steaming slowly ahead, drew the gun up to its position.

THE ENGLISH NAVAL BRIGADE AND BATTERIES IN EGYPT.

By Lieutenant Charles F. Norton, U. S. N.

Naval Brigade.

There was no regular brigade organization. A landing party was sent on shore from each ship, consisting of one Gatling gun with crew and an infantry support. The companies from the large vessels were composed of eighty men, armed with the Martini-Henry rifle, sword-bayonet and one hundred rounds of ammunition per man. One long Gatling gun with a crew of eighteen men, each man being armed with cutlass and revolver, and sixty rounds of revolver ammunition per man, and two thousand five hundred rounds of ammunition per gun. Two pioneers with shovel and pickaxe, four stretcher-men and one hospital steward went with each company. In addition to arms and ammunition, each man was provided with leggings, blanket, water-bottle, and haversack holding two days' rations.

The first force consisted of one thousand men and thirteen Gatling guns, and they were distributed about the city at different gates and weak places in the walls. I was unable to learn the special distribution of the forces. One hundred and fifty men were detailed for patrol-duty, to stop looting, extinguish fires and arrest all suspicious persons.

The day following the first landing, twenty 9-pdr. naval guns were landed with their crews, but they embarked in a few days; that is, as soon as the army landed.

Each section was commanded by a sub-lieutenant or midshipman; each platoon by a lieutenant. The infantry companies were commanded by lieutenants. Two 9-pdr. naval guns with fifty men, supported by half a battalion of the 38th regiment, took part in the reconnoissance of August 5th. They were stationed along the banks of the railway leading to Cairo and did excellent work. The last of the naval forces embarked on September 16th, 1882.

Naval Batteries.

There were three naval batteries at Alexandria, viz.: three 9-pdr. naval guns at Fort Kom-el-Dik, three 7-inch Armstrong rifles, flanked by two 9-pdr. naval guns at Ramleh, and the armored train, consisting of one 40-pdr. rifle, two 9-pdr. naval guns, one long Gatling and one Nordenfeldt. Fort Kom-el-Dik is a redoubt situated just inside the city walls, near the Moharrem Bey gate.

At Fort Kom-el-Dik the guns were on field-carriages and placed on platforms of timber just high enough to allow the guns to overlook the parapet. An embrasure was made by building up sides with sand-bags. The sides were three feet high and were placed at right angles to each other. Between these faces and immediately in front of the guns the top of the parapet was dug away to allow two degrees depression to be given to the guns. Each gun was manned by eighteen men armed with cutlasses and revolvers. The guns were supplied with twelve shell, percussion fuze, and twelve shrapnel, time-fuzes. No. 1 commanded the outside approach to Moharrem Bey gate and a broken place in the city wall, which was afterwards repaired by the British. No. 2 commanded the approach to Kom-el-Dik on the eastern side. No. 3 commanded the approach to the fort from the Rosetta Gate or northeast face. Stationed in the same fort was one company of the 60th Rifles as an infantry support.

At Ramleh, after its occupation by British troops, a naval battery of three 7-inch Armstrong rifles on broadside carriages, and two 9-pdr. naval guns on field-carriages, was established. The Armstrong guns were taken from the Ras-el-Tin forts and taken to Ramleh by train on the Rosetta branch of the Egyptian railway. At the eastern end of a cut, just in front of the Ramleh water-tower, the guns

were removed from the cars. They were then transported on rollers, made by lashing handspikes together, to the platforms built for them. Stout timbers were placed in the ground, at intervals, for leading blocks. A six-inch hawser was secured to the slide, rove through large single blocks as fair leaders, and then fastened to a twenty-ton locomotive on the track. The platforms were made of two layers of timbers 8″x 10″ on the end and about 16′ long. The timbers of the top layer were laid across the lower ones. Two curved tracks a quarter of a circle in length were spiked to the timbers for the trucks of the slide to travel on. For the pivot-bolt, a gun was planted in the ground, muzzle up, the bolt working in the bore of the gun. Tripods of handspikes stood on the right of each gun for holding rammers, sponges, &c. The guns were mounted about one hundred yards apart and behind the embankment made by the railway cut. There were no embrasures.

The most easterly gun, or No. 3 of the battery, was differently mounted. The trucks had been taken off the slide, and the slide rested directly on the timbers. The front end of the slide was chained down. As this gun could not be trained laterally, no gun was planted for pivot-bolt. At the rear end of the slide was a backing of timber and earth to stop the gun-carriage in case the compressor failed to act. About twenty feet in rear of this gun was a temporary magazine capable of holding about eight tanks of powder. The main magazine was situated between No. 2 and No. 3 gun, and was built in the embankment of the railway. It was timbered on the two sides and top. The entrance and top were defended by sand-bags and earth. I did not learn the amount of powder, but they had one hundred and seventy shell ready for use. This battery was used against the Egyptian works at King Asmon, a distance of 5500 yards. Two hundred and fifty yards to the rear and right of this battery were the 9-pdrs. on field-carriages. A trench about two feet deep had been dug around the brow of the hill in front of the camp and the earth thrown up, making earthworks about three feet high. The embrasures were faced with sand-bags. Eighty men were detailed for this battery, and they lived in army tents on the hill just behind the guns.

The entire work of transportation and mounting of guns was done by the navy, except the erection of one platform, which was done by the Royal Engineers.

ARMORED TRAIN USED BY THE FORCES AT ALEXANDRIA.

By Lieutenant Nathan H. Barnes, U. S. N.

The armored train used by the English forces against the Egyptian insurgents under Arabi Pasha, varied somewhat at different times, according to the force it carried, but may be regarded as consisting of six different parts, as follows:

First, one or more vacant platform cars, intended to feel the way and give notice of any obstructions upon the track before they are reached by the more important parts of the train, or to take the shock of torpedoes.

Second, a platform car carrying one gun, a 40-pdr. Armstrong of old pattern, so arranged as to admit of training about four points upon either side. It rests upon a solid platform of wood four inches thick, in which is fitted a pivot which holds the slide, and, with a breeching hitched to a bolt on each side of the car, checks the recoil. This car is unarmored except at the front end, where, inside the wooden end wall, is an iron plate three-sixteenths of an inch in thickness, inclosing on three sides a wooden box, three feet in thickness and as high as will permit the free working of the gun, the box being filled with bags of sand, and a few others hanging from the plates on the sides. At the rear end of the car is a wooden wall about three feet high, on which are hung the implements for serving the gun. On the floor, near by, are carried a few rounds of ammunition.

Third, the locomotive. This is protected on each side by three bars of railroad iron hung with wire, partly covering the boiler, and an inch plate of iron, about two feet by four, covering the cylinder, the piston-rod and its connections. The caboose is protected by iron plates, three-sixteenths of an inch in thickness, backed with bags of sand. Although the most vital, this is the weakest part of the train. A large part of the boiler and a considerable portion of the machinery are exposed, but can hardly be better protected, as the springs will not sustain any additional weight. Its armor is the heaviest, but it is not complete. I think lighter armor, more completely shielding the locomotive, would be preferable, for the train can hardly expect

to withstand even the fire of field guns, unless at long range, and the rest of the train is designed to be proof only against musketry.

Fourth, a platform car protected on all sides by a movable wall two inches thick, backed with iron plates three-sixteenths of an inch thick, and sand-bags; the sides of a height convenient for firing over by men kneeling upon the lower tier of sand-bags. Around the walls hang a supply of intrenching tools, such as picks and shovels, and at one end lies a pile of a dozen stretchers. On each side, outside, is lashed a small spar, a handspike, and several looms of oars, or similar small pieces of wood, with short pieces lashed across their ends. These are designed for carrying the gun in case of need. By lashing one of the spars on top of the gun and crossing the other pieces under it, the latter, with the short pieces at their ends, will permit fifty men to get a good hold without crowding. This car is intended to carry a force armed with rifles.

Fifth, a car, similar to the one just described, and protected in the same way, armed with a Gatling in front and a Nordenfeldt in rear, between which is carried a supply of ammunition—5000 rounds for the former and 12,000 for the latter. This car also carries intrenching tools.

Sixth, a platform car protected in the same way as the last two, carrying two 9-pdr. rifled howitzers, with a small supply of ammunition. They are intended principally for service off the train, and heavy skids are carried for convenience in putting them off or taking them on the car.

At times another car is attached to the train, protected like the rest, except that the rear wall is higher and has a port where a Gatling is mounted.

A number of drag-ropes are carried, so that in case of any accident disabling the locomotive, the men may man them on the side away from the enemy, and thus draw the train while retreating.

One of the cars usually carries a tripod of small spars surmounted by a platform, forming a lookout, elevated twenty feet above the train, which commands a good view of the country, and makes it difficult for the enemy to conceal his men behind small irregularities of the ground.

A second train closely follows the first as a supply and relief train. The front end of its advance car carries a steam derrick intended for use in clearing away wrecks. If a car of the fighting train should be disabled by the enemy's fire or from any cause, the relief train

would draw away the car in rear of it to the nearest switch (and there is one near the point of operations), then return, and with the derrick dump the wreck clear of the track, after which it would draw away the rest of the train. The train carries tools and materials for repairing the track or even laying a new one, should it be cut or torn up in their rear; also gun-cotton, torpedoes, an electric battery and wires for destroying by explosives whatever it may be advisable thus to get out of the way.

A most interesting and elaborate feature of the supply train is a magazine car—a platform car protected by wooden walls and iron plates like those of the fighting train. The magazine is in front, and further protected by a solid wooden backing of twelve inches on all sides except in rear, where it is open, leaving a space high enough for a powder tank; it is covered with a half-inch iron plate, bars of railroad iron laid close together, and above all, bags of sand. The rear half of the car is divided by pieces of plank laid across, into compartments, in which are stowed shell, shrapnel and canister for both the 40-pdrs. and the 9-pdrs. The ammunition is carried by hand from the magazine car to the fighting train, the men running along the railroad under shelter of its embankment. The supply train also carries a few passenger cars, used as quarters for officers and men, and two box cars for their cooking and messing arrangements, but these are never taken beyond the junction near the English lines at Ramleh. At present these trains pass the day at the freight depot in this city, but at 8 P. M. go out, pass the night reconnoitring between the English and Egyptian lines, and at 6 A. M. return to the city.

For a time it was claimed that the armored train did excellent work, but I cannot learn that it was used except as an auxiliary to reconnoitring parties. I do not regard it as of much military value, for its operations are limited to one track, and it can be easily avoided or successfully opposed by heavy guns mounted near the track. Arabi Pasha has adopted the latter means, and with 3-inch rifles has made it dangerous for the train to approach nearer than 6000 yards to his fortifications, which is about the distance of the English lines. The train is armored only sufficiently to withstand rifle fire, nor can it well be protected against the fire of any guns as heavy as it carries. As Arabi's guns are effective at 6000 yards and the heaviest on the train at not more than 3500, it is obvious that at present the train is of little use, but it is intended to increase its efficiency by mounting upon it a 9-inch rifle.

It was at first intended to advance to the attack supported by a skirmish line, but that plan has been abandoned, and the force, originally two hundred men, is now reduced to fifty. The train's first use was attended with considerable fighting and it went through one prolonged engagement, but its operations are now limited to an occasional shot with its heaviest gun, which accomplishes little. The train has been manned and operated entirely by blue-jackets from the fleet.

THE SEIZURE OF THE SUEZ CANAL.

The seizure of the Suez Canal, an event which will form a point of new departure in the history of the world, fell, in like manner as did the bombardment and occupation of Alexandria, to the share of the navy. From Suez, Rear-Admiral Hewett, after landing 450 men, in the face of more than four times that number of Egyptian troops, was able to telegraph to the Admiralty, with that brevity for which this gallant officer is celebrated, "Have occupied Suez. Enemy fled." At this time, Mr. Ferdinand de Lesseps was at Ismailia, assuring Arabi Pasha that he guaranteed the neutrality of the canal. Sir Garnet Wolseley had arrived at Alexandria, and the English troops had been there landed. The general officers commanding divisions and brigades had been in daily communication with the admirals of the fleet on board the Salamis; and Rear-Admiral Hoskins was dispatched in the Iris to Port Said on August 16th. He reached his destination the next day, and took command of the ships in the Suez Canal. From his flagship, the Penelope, he issued orders to the Nyanza, condenser ship, to take on board 100 seamen and marines of the Northumberland, and to proceed with tents and provisions to Ismailia to reinforce Captain Fitz Roy, of the Orion. That officer was also ordered to occupy Ismailia some time before daylight on Sunday morning, August 20. These orders deserve to be recorded in full for future reference. They ran as follows:

(*Memo.*) H. M. S. PENELOPE, *Port Said*, *August* 18, 1882.

Some time before daylight on Sunday morning next, you are to land the available force under your command at Ismailia, and proceed to occupy the town, which you are to hold until you are reinforced, which will probably be, at the latest, within twenty-four hours.

It is of the greatest importance that the telegraph offices, both of the Canal Company and the Egyptian Government, should be seized at once, and all telegrams prevented from passing. The waste weir to the westward of the upper lock should also be seized at once, and held, if possible, until the troops arrive. As this is under the fire of guns at Nefiche, intrenchments should be thrown up as soon as possible to cover the men. You are to use your own discretion as to supporting this movement with the fire of the ships, but you will bear in mind that it is most desirable that no injury whatever should be done to the town of Ismailia, or its inhabitants, by any measures which you adopt yourself, and you should use every means in your power to prevent it on the part of others. The Staff Commander of the Orion should be ready to place any ships arriving with troops in the best berths for them to occupy with a view to the disembarkation and their draught of water. From the verbal communication we have had, the support you may expect from myself and Sir William Hewett is made fully known to you. In the event of your being attacked by a superior force of the enemy, you are to use your own discretion as to falling back upon the ships. Any person attempting to set fire to the houses should at once be shot.

A. H. HOSKINS, *Rear-Admiral.*

To Captain R. O'B. FITZ ROY, *H. M. S. Orion.*

To Captain Henry Fairfax, C. B., A. D. C., of the Monarch, and to Captain Edward H. Seymour, of the Iris, was entrusted the task of seizing Port Said. The following orders were issued to these officers:

PENELOPE, *at Port Said, August* 19, 1882.

At 3.30 A. M. on Sunday next, the 20th instant, Port Said is to be occupied in the following manner:

2. The direction of operations will be under Captain Fairfax, of H. M. S. Monarch.

3. The landing party will consist of—from H. M. S. Monarch, 100 seamen, small-arm men, 18 Gatling-gun crews, 48 Royal Marines, 1 Gatling gun. From H. M. S. Iris, 80 seamen, small-arm men, 18 Gatling-gun crews, 28 Royal Marines, 1 Gatling gun. From H. M. S. Northumberland, battalion 200 Royal Marines. Total, 180 seamen, small-arm men, 36 Gatling-gun crews, 276 Royal Marines, 2 Gatling guns. Total strength, 492 men and 2 Gatling guns.

4. The Iris seamen and marines will at once proceed to the outskirts of the town by the Quay Eugénie, and take the right of the line, to extend from the sea to Lake Menzaleh, between the European and Arab town, *i. e.* from the right of the Rue du Nord to the beach.

5. They will be followed immediately by the company of the battalion of marines from the Iris, who will turn to the left at the Rue de l'Arsenal, and form round the north angle of the barracks.

6. The Monarch's seamen and marines will form on the wharf opposite the ship, and march by the Rue du Nord to the Consulate, which the marines will take charge of, posting sentries. The bluejackets will continue on the same line of the street, and form on the left of the Iris's men, extending to Lake Menzaleh, and detaching a party to guard the reservoir and its neighborhood.

7. The battalion company of Royal Marines of the Monarch will form on the left of the above, on the wharf, and march after the advance to the south corner of the barracks, taking care not to extend into the Rue de l'Arsenal, so as not to be in the way of the fire of the Iris's detachment. The Egyptian troops are to be summoned to lay down their arms and then marched down to the wharf.

8. One Gatling gun will accompany the advance of the Iris, and the other, the marine battalion company of the Monarch, to the entrance to the barracks.

9. A sergeant's party is to be kept on the wharf to prevent any attempt being made to fire the Custom House, round which sentries are to be posted.

10. The Khedive's Governor, now in Poona, will be on board the Penelope, and land directly the occupation is effected, and aid in the maintenance of order with the police, who are known to be loyal.

10*a*. Arrangements are to be made to send the breakfasts on shore, with anything else that may be wanted, at about 7 A. M. The men to have a meal of cocoa before landing.

11. Care is to be taken that men do not land with loaded rifles, or load without orders; and it is to be impressed on all the landing party that no firing is to take place without orders, and that it is of the greatest importance to preserve amicable relations both with the white inhabitants of all nations and also with the Arabs, on whom we are dependent for the coaling of our ships.

12. A guard must be placed by the Iris over the Governor's house at the earliest opportunity. Arabi's Governor, Rouchdy Pasha, is to be received as a friend, if he surrender himself.

13. It is very desirable to secure the Bimbashi, if possible, and Major Tulloch, with an interpreter and a small party of picked men, will endeavor to effect this. Prisoners should be put on board the Iris, when the Governor has been consulted as to who should be released and who retained as such.

14. Marines will land in blue, with helmets; seamen in blue, with white cap-covers. As soon as possible a change of white clothing and hats for the seamen should be sent on shore, and strict attention to be paid to their appearance on parade and their general tone and bearing. All defaulters are to be sent at once on board the Monarch. A patrol of trustworthy men under an officer is to be told off at once for the maintenance of discipline amongst our own men, and such patrols as may be necessary to support the Egyptian police must be forthcoming immediately the occupation has taken place. Major Tulloch will be good enough to attach himself to the Governor, *pro tem.*, in order to ensure requirements for the maintenance of order being promptly made known to Captain Fairfax, or the officer deputed by him. Captain Seymour will carry out independently my private orders to him. Captain Fairfax will act as military commandant of Port Said during my absence, until the pleasure of the Commander-in-Chief is known.

A. H. HOSKINS, *Rear-Admiral.*

To Capt. HENRY FAIRFAX, *C. B., A. D. C., of H. M. S. Monarch; and Capt.* EDWARD H. SEYMOUR, *of H. M. S. Iris.*

To Commander Edwards, of the Ready, the following orders were given:

PENELOPE, *at Port Said, August* 19, 1882.

Commander Edwards, of H. M. S. Ready, will start soon after dark this evening, with boats containing one company of the Northumberland's landing party. He is first to occupy the dredges, putting on board each an officer and fifteen men, to prevent any communication with the shore, and to ensure each dredge being kept close to the bank, out of the way of the passing ships. Four days' provisions are to be put on board with each party. Having done this and given his orders to the officers, he is to proceed to Kantara and seize the telegraph office, and both the Egyptian and Canal company's wires, and allow no message to pass through till he is certain that it is made either by us or in our interest. Having done this, he is to take steps to ensure all the ships in the canal between Port Said and Lake Timsah bound north, *i. e.* to Port Said, being gared.

The forces placed under the orders of Commander Edwards consisted of seven officers and ninety-four men of the Penelope and Northumberland, as also that ship's picket-boat, a torpedo boat of the Iris, a steam cutter of the Tourmaline, and a steam pinnace of the Monarch. Rear-Admiral Hoskins, in his report, states that:

"6. M. Victor de Lesseps, who is the working head of the Canal Company at Ismailia, came on board on the 17th inst., and entered into a long discussion, presenting a series of arguments against any possible intention on our part to disembark in the canal, and disputing the grounds of my intimation that I considered Ismailia, both town and port, to be Egyptian. He left with the conviction, I feel sure, on his part, that we, sooner or later, should use the canal for a military purpose; while I had imbibed a conviction that no remonstrance on our part would induce Count Ferdinand de Lesseps to willingly accept the position, and withdraw his opposition to our doing so.

"7. I considered, therefore, that to insure the safe passage of our troops, it was absolutely necessary that the barges and dredges, &c., should be occupied along the whole line of the canal to Ismailia; and further, that it was most desirable that the Kantara telegraph station should be seized, and our through telegraphic communication be restored, while Arabi's communication with Syria should be stopped.

"8. For this duty I selected Commander H. H. Edwards, of H. M. S. Ready, as an officer thoroughly conversant with the canal, and in whose judgment I had confidence.

"9. He started at 8 o'clock on Saturday evening, the 19th inst., taking the necessary telegraphists, and left the parties told off for each post as he passed up."

And in a postscriptum adds: "My report would not be complete without my mentioning that I employed Captain Seymour, of the Iris, on the delicate duty of securing the Canal Company's office at Port Said, and preventing any information being conveyed through it to their other stations or to the rebels—a duty which was performed, as have all others on which I have employed Captain Seymour, entirely to my satisfaction."

Captain Fitz Roy, in a dispatch dated August 21, describes his operations in taking possession of Ismailia, the Arab town, and advancing sufficiently towards Nefiche to cover the weir. The force landed consisted of 565 officers and men. The enemy were known to

have a strong picket at Arab town, several patrols and a guard at Ismailia, about 2000 men and six guns encamped at Nefiche, and a considerable number of Bedouins in the neighborhood. At 3 A. M. on the 20th, in perfect silence, the men landed and advanced, the silence being so perfect that Commander Kane surrounded the lock guard before they were discovered. The lock guard fired their rifles, so did our men, and Commander Kane was wounded by a rifle bullet on the left cheek. The Governor's guard laid down their arms to Lieutenant Lennox Napier, commanding the Coquette, in command of one of the landing parties, and Lieutenant Swinburne, of the Northumberland, in command of the Royal Marine Artillery. No further resistance was experienced in the town of Ismailia. Commander Kane, of the Alexandra, seized the railway and telegraphs, and with the assistance of Major Fraser, R. E., commenced sending false messages to Arabi, to deter him from advancing upon Ismailia while the British force was numerically so weak. Hence, Major Fraser telegraphed that 5000 British troops had surprised the town and landed. The landing party of the Orion seized the Canal Lock Bridge and Government House, and Captain Fitz Roy therein established his headquarters. But few of the enemy were killed. Everywhere the Egyptians either surrendered or fled. The ships at 3.30 A. M. bombarded the guard-house in Arab town, the Orion and Carysfort each firing five rounds of shell. By 4 A. M. the whole of Ismailia was occupied. Learning from intercepted telegrams that Arabi was making arrangements to forward a large force from Nefiche, "to drive the English into the canal," Captain Fitz Roy wisely determined to dislodge the enemy from Nefiche. He therefore ordered the Orion and Carysfort to commence a slow bombardment.

From neither of these ships was the object to be fired at visible. The range of the Nefiche railway station was ascertained from the chart, to within a foot. The direction was obtained by compass by Lieutenant Royds from the masthead of the Carysfort. A remarkable instance of scientific gunnery was the result; the precision with which the ships fired was truly wonderful. The distance was about 4200 yards. At 11 A. M. both ships commenced a slow bombardment. By noon the camp of the rebels had become too hot to hold them, and they were retreating towards Kassassin. A train, running south, was severely hit and stopped for a time, but at about 4 P. M. a train, seen to arrive on the Cairo line and commence discharging men, was fired at, the guns being laid by compass bearing. This train was

completely wrecked; its trucks were overturned and jammed in such a manner as to entirely block the line and stop all communication between the rebel forces to the southward and those at Tel-el-Kebir. The ships were under the command of Commander Moore, of the Orion, Lieutenant Royds having charge of the Carysfort. The bombardment of Nefiche did not cease until 10 P. M., after which shells were fired only every half-hour, to make the position at Ismailia perfectly secure. Not before 6 P. M. did reinforcements, consisting of 340 marines, arrive; and all this time the little force at the disposal of Captain Fitz Roy had been opposed to from 2000 to 5000 of the enemy, Arabi himself advancing to Nefiche with 3000 men, but having to retire before the shells of the Orion and Carysfort. Commander Edwards proceeded up the canal to stop the traffic and gare all ships. The Messageries maritime steamer Melbourne defied Lieutenant Barnes-Lawrence, who had been detached in the torpedo boat of the Iris, and insisted on proceeding on her course, the master of the steamer stating that nothing but armed force would compel him to gare his vessel or let go the anchor. Lieutenant Barnes-Lawrence, not considering that his instructions warranted the use of force, left the French steamer to pursue her course, and proceeded to report the occurrence to Commander Edwards. Two British steamers, the Ross-shire and the Counsellor, thereupon weighed and followed the French steamer, in direct disobedience of the orders they had received. Had a mishap occurred to any of these steamers, whereby the canal became blocked, the landing of the English army would have been seriously delayed. Captain Fairfax, of the Monarch, surprised the rebel garrison at Port Said, and took possession of the town, with 216 seamen, 276 marines, and two Gatling guns. Major Tulloch, Royal Welsh Fusileers, who gave Captain Fairfax much valuable information and assistance, landed first, with six marines, and surprised Arabi's sentries, capturing three out of four posted. 160 rebels surrendered and laid down their arms. Many of these subsequently deserted to the rebel forces at Damietta. The remainder were rearrested and confined on board the Northumberland. The Khedive's Governor was reinstated, and Admiral Hoskins issued the following proclamation:

"*Proclamation*:—H. H. the Khedive having giving the Admiral commanding the British fleet authority to take charge of all places in or near the Maritime Canal as may be necessary for operations against the rebels, Rear-Admiral Hoskins, commanding the British

vessels in the Maritime Canal, now takes possession of Port Said for the purpose indicated, and trusts that all the inhabitants will assist him, as far as lies in their power, in maintaining order and protecting life and property. The Governor, Ismail Pasha Hamdy, appointed by H. H. the Khedive, will resume his office, and conduct his duties as formerly. The Captain of H. B. M. S. Monarch will act as military commandant of the garrison, and be responsible for the defense of the town against the rebels, and the support of the Khedive's civil authorities against any attempt that may be made against life or property. The police patrols, which will consist of English soldiers and Egyptian police, will at once arrest all persons causing disturbances, more serious crimes being dealt with by martial law. The Rear-Admiral trusts that all business will be conducted and the affairs of the town go on in the ordinary course under the rule of his Excellency the Governor.

"A. H. HOSKINS,

"*Rear-Admiral Commanding H. B. M's ships in the Maritime Canal.*"

We now come to the part played by Rear-Admiral Sir William Hewett, V. C., in the seizure of the canal. He at once seized Suez, the enemy retreating before his small force. He saved Suez from being pillaged and delivered to the flames as was Alexandria. On Aug. 17 he received a telegram from Sir Beauchamp Seymour, requesting him to act on instructions that would be conveyed to him through Rear-Admiral Hoskins. These instructions reached Sir William Hewett on Aug. 18. He immediately put in train the work to be carried out at Suez. Brig.-General Tanner was consulted. The Seaforth Highlanders were detained at Suez, the Naval Brigade being considered too weak to hold that town against the large force the enemy was known to have concentrated outside. The telegraph wires between the town and the first canal lock, through which the enemy was receiving news of the English movements, were cut, and a guard was put over the office. Notices were issued that from August 19th no ship would be allowed to enter the Maritime Canal, and the Mosquito was placed at its mouth. At the time when it was decided to detain the Highlanders, the regiment was already on board the Bancoora. This was on Saturday night, and their disembarkation on Sunday, Aug. 20th. On Sunday morning, at daylight, four hundred Highlanders, under Colonel Stockwell, were disembarked from the transport, and marched eight miles in the

direction of Chalouf, to make a feint attack in our front. Brig.-Gen. Tanner, C. B., accompanied this force, and at the same time Captain A. P. Hastings, in the Seagull, with the Mosquito in company, and two hundred of the Seaforth Highlanders, proceeded to Chalouf by the Maritime Canal. The party under Colonel Stockwell returned to Suez at about 4 P. M., without having touched the enemy; but later in the day Captain Hastings returned in a steam pinnace, to report to Sir William Hewett very successful operations from the gun-vessels. It appears that the first that was seen of the enemy along the canal was a small cavalry patrol, about three miles on the Suez side of Chalouf, and on arrival at Chalouf his presence in force was only discovered by a few heads appearing over the railway embankment on the other side of the Sweetwater Canal, this embankment forming a natural entrenchment, behind which it was afterwards discovered there were some six hundred infantry, ready to resist the advance of the British. These men were extremely well armed and accoutred, and had a plentiful supply of ammunition with them. The manner in which the position was taken reflects the highest credit on Captain Hastings. The coolness and dash of the Highlanders and the excellent fire from the ships' tops seem to have been the chief causes of success, and the conduct of all concerned appears to have been in every way creditable. Credit must be given to Lieut.-Colonel Helsham Jones, R. E., for the fact of fresh water having been saved at Suez. Opening the lock-gates above the point occupied kept the canal below full, notwithstanding the waste which took place through a breach made by the enemy in the banks, which was, however, afterwards repaired by a company of the Madras Sappers. The action taken at Chalouf did much to secure the safety of the canal, and as the Indian forces were fast arriving, the Highlanders were sent on to Serapeum on Aug. 22. In this manner the Suez Canal was seized from end to end, and by sunset on Sunday, Aug. 20, was in the possession of the officers and men of the British Navy.

LORD CHARLES BERESFORD ON MACHINE GUNS.

Having always recognized the immense utility of machine-guns since first they were introduced, I was delighted to see such clear details given of the Nordenfeldt class in the *Army and Navy Gazette* of October 28. In my opinion, machine-guns, if properly worked, would

decide the fate of a campaign, and would be equally useful ashore or afloat. When the Gatling guns were landed at Alexandria, after the bombardment, the effect of their fire upon the wild mob of fanatic incendiaries and looters was quite extraordinary. These guns were not fired at the people, but a little over their heads, as a massacre would have been the result had the guns been steadily trained on the mob. The rain of bullets which they heard screaming over their heads produced a moral effect not easily described. I asked an Egyptian officer some weeks afterwards how on earth it was that Arabi and his 9000 regular troops, who were within five miles, did not march down upon the town in the first four days after the bombardment, when Arabi knew that Captain Fisher's naval brigade, which held the lines, numbered less than 400 men. The Egyptian officer replied that he knew no army which could face machines which "pumped lead," and that as all the gates were defended by such machines, as well as having torpedoes under the bridges, such defenses could not be faced. This certainly was the case. I believe the Egyptian officer spoke the truth, and that the moral effect produced by the Gatlings on the people in the first landing prevented the army from attacking the diminutive force which held the lines afterwards. The English navy is far behind other navies (notably the French) in the proportion of machine-guns to the fleet. The French have nearly double the number of machine-guns in their first-class ships that the English have, and from two to eight machine-guns in all their small craft; while the English have, except in a few exceptions, no machine-guns at all in their small craft. Some naval officers object to the many machine-guns in French ships, because, they say, they are so exposed. So they are, and they must necessarily be so, to be in an effective position. But everything on board a ship is a compromise, and if the machine-gun is knocked over and the two men working it are killed, it is only the loss of one gun and two men; whereas, before that contingency occurs, imagine what must be the actual and moral effect of pumping bullets through a port or on to a deck, or anywhere about a ship, at the rate of 700 a minute from each of ten machine-guns, or, in all, 7000 bullets a minute. It would be impossible to fire too quickly during the time the sights were on any vulnerable part, such as I have described, of the enemy's vessel; and as a ship is her own magazine, there is no danger of running short of ammunition during an action. With the object of having the greatest rapidity of fire possible, I would have none but magazine rifles on board men-of-war.

The French and Americans have adopted this plan. The principal difficulties with machine-guns are (1) finding the range, and (2) the difficulty of making the man who is laying the gun keep his eye on the sights so as to keep continually training the gun on a small arc, and thus scatter the bullets, which, if not done, wastes ammunition, as only one man of the enemy might be killed, and that with twenty bullets. Both these difficulties are momentary, and have been nearly overcome by Mr. Nordenfeldt. With a large number of machine-guns on board a ship carefully worked, I believe it to be perfectly possible to rain bullets through an enemy's port so that it would be impossible for the captain of a gun in the enemy's ship to get his sights on. This idea is peculiarly applicable to an enemy who carries muzzle-loading guns. Foreign navies have adopted the machine-guns which are allowed by international understanding to throw shell. I refer to those guns which throw projectiles of one pound and upwards. Nordenfeldt guns of this description fire at an average rate of twenty-five rounds a minute, but being shell guns, the effect produced is equivalent to ten times that number of bullet rounds. I would like to see an equal number of shell and bullet machine-guns in every ship. My belief in machine-guns is such that when the Khedive sent for me at the beginning of the campaign in Egypt, and told me he hoped to form a contingent of Bedouins, and that he should ask me to take command of it, I begged his Highness to allow me to at once proceed home and purchase a battery of six Nordenfeldt guns instead, which I would have mounted on a plan of my own, *i. e.* on a long, low carriage with four wheels, no limber; ammunition and necessaries stowed in rear of gun on carriage, the carriage to be in two pieces, divided in the centre, but secured together by a strong bolt, on which it would pivot in turning; wheels well away from the carriage, so as to gallop safely over rough ground. These guns would have been driven with a pair of horses, like a fire-engine, the gun's crew to consist of seven men, three on the carriage, the other four to ride, being in no way attached to the gun, but being available to hook in immediately if a casualty occurred to one of the driven horses. An awning or shield should be on the carriage, to protect the men working the gun and the driven horses, as far as possible, when in action. A favorable opportunity occurring, machine-guns mounted in this manner could gallop up in skirmishing order, so as to show as little target as possible, to within 600 or 800 yards of the enemy, and when once in action, if well handled, would simply

massacre the enemy. Provided a most improbable contingency was to occur and the whole battery was lost, the guns could be easily disabled before falling into the enemy's hands, and the gun's crew, consisting as they would of so few men, would be but a trifling loss to the army. I consider Mr. Nordenfeldt's guns the best machine-guns yet produced, for the reason that they have an equal capability with others, but are far lighter. I should like, however, to see a fair and square trial between all the different classes of machine-guns, so as really to ascertain which is the best system all round. I believe the day cannot be far distant when there will be a machine-gun of suitable calibre attached to each arm of service on shore, *i. e.* the artillery, the cavalry, and the infantry; and if properly worked, such guns must seal the fate of a campaign. I have sent Mr. Nordenfeldt my plan for a galloping machine-gun, which he is perfecting for me for experiment, and which I believe would be a most excellent weapon to attach to the cavalry.

MEMORANDA.

Machine Guns in Egypt.—The value of machine guns was practically demonstrated by the Condor during the bombardment of Alexandria. Ships of the Condor class not being supplied with these arms, Lord Charles Beresford applied to Admiral Seymour to be allowed to borrow a Nordenfeldt gun from one of the ships present. This request was granted. Lord Beresford had this gun mounted in the foretop of the Condor. A small six-pounder boat-gun was sent into the maintop, while the rocket-tube was lashed to the bowsprit. A rapid fire was kept up from these during the engagement, the machine gun firing right into the embrasures. Its volleys delivered in quick succession visibly inconvenienced the Egyptian gunners, who became more and more demoralized the oftener the works around them were struck. As long as the fire from the tops was kept up, the enemy hid himself, and appeared again only when a lull occurred in the firing while fresh ammunition was being procured. All this time the Condor's pivot-gun did excellent work. The fort was struck so often that the Egyptians seldom dared to expose them-

selves. The demoralization of the Egyptians was mainly due to the terrific fire from the foretop of the Condor.

Reports from Alexandria all concur in testifying to the great assistance rendered to the bombardment by the machine guns attached to the fleet, more especially in driving the men in forts Ada and Pharos from their guns. These guns fired between thirty and forty thousand rounds while the ships were engaged with the forts, and it is to this continuous hail of bullets pouring into the embrasures that is attributed the unsteadiness of the enemy's fire, and in a great measure the rapidity with which the Egyptians were driven from their guns. In two instances it was found that the chilled steel shot had buried themselves between the grooves within the bore of the enemy's guns, completely disabling these pieces, which could no longer ram home their charges. Had they been loaded at the time and afterwards fired, the probabilities are that the muzzles of those two guns would have been blown off, or would have burst at the point where the shot was lodged within and consequently choked the bore.

The Nordenfeldt gun, in particular, seems to have proved its worth in naval warfare. It is stated that the English navy will be supplied with a new Nordenfeldt, carrying a 9-pounder shot and shell. The naval machine-gun battery used at the front was formed at Ismailia, and consisted of 197 seamen, 15 officers, and six Gatling guns. Allowing 18 men and two officers as a crew for each Gatling gun, there would remain a company of about 45 files and three officers to act as escort to the battery, fill up casualties and guard the guns from surprise both on the line of march and in action. Had lighter guns than the Gatlings been employed, from eight to ten men would have been saved to each gun's crew.

Electric Signals at Alexandria.—The *Standard* correspondent on board H. M. S. Invincible, which was stated to be distant seven miles from the cable-ship Chiltern, telegraphs as follows at 9 P. M. on Wednesday, July 12th: "The Chiltern is endeavoring to obtain replies to the Queen's message about the wounded, by signalling with the electric light to the various vessels of the fleet. The signals can be read with perfect ease, and could be so were the Chiltern lying at several times her present distance."

Military Balloons.—Three officers were appointed to proceed to Egypt with the balloon equipment, namely, two officers from the Royal Engineers and one from the King's Royal Rifles. They were to take with them the three largest of the War Department balloons,

which were the Crusader, containing 27,000 cubic feet; the Talisman, 18,000 feet; and the Saracen, 13,000 feet. Each balloon was to be fully equipped, in order that all three might, if required, be separately employed; and a party of sappers, already trained to the work, were to be attached to each of them. It was not determined where they were to go. If to Alexandria, they would find convenient gas-works; but in case ascents were necessary at a distance from populous places, they would take with them materials for the generation of hydrogen gas, not by the action of steam, as in the Woolwich experiments, but by the simpler chemical process. It is not known whether these balloons were sent.

Post-Office Corps.—In compliance with a royal warrant promulgated through the Secretary of State for War, August 10th, a Post-Office Corps was formed for military service in Egypt, composed of officers and men of the Post-Office Volunteer Corps who were willing to join the new corps, and could be temporarily spared from the General Post-Office. The servants of the post-office being volunteers, those who could obtain the permission of the Secretary of the General Post-Office were enlisted as soldiers of the regular forces for a period of six years—three years' army and three years in the reserve—to be disbanded within six months of the termination of hostilities. One hundred men are required for this service; forty were retained for army service, and the remainder immediately passed to the reserve, to be called up as they might be required; eight of the forty were promoted to rank as sergeants and corporals. The establishment was as follows: One army postmaster, one assistant ditto, four sergeants, four corporals and thirty privates. They receive extra pay, varying from 10 shillings to 1 shilling a day, in addition to the ordinary pay received from the post office. Advance pay is granted prior to embarkation. Officers and men wear present volunteer uniforms; non-commissioned officers and men are armed with sword-bayonet and revolver. The employés can be transferred to the reserve forces at any time during their period of army service, or be discharged when they cease to be employed in the post office. The age on entering the corps is fixed at from nineteen to thirty years, height 5 feet 4 inches and upwards, and chest measurement 32 inches. No recruits will be eligible unless employed in the post office, or members of the Post-Office Volunteer Corps. The consent of the Postmaster-General has to be obtained prior to enlistment.

Cost of Firing.—Every round fired during the bombardment of Alexandria from the four 80-ton guns of the Inflexible cost £25 10s.

per gun. The 25-ton guns, of which the Alexandra carries two, the Monarch four, and the Téméraire four, cost £7 per round per gun. The 18-ton guns, of which the Alexandra carries ten, the Sultan eight, the Superb sixteen, and the Téméraire four, cost five guineas per round per gun. The 12-ton guns, of which the Invincible carries ten, the Monarch two, and the Sultan four, cost £3 12s. per round per gun. The Penelope, which alone carries 9-ton guns, has eight of them, which were discharged at a cost of £2 15s. per round per gun. The Monarch and the Bittern each fired one 6½-ton gun, the cost being £1 15s. per round per gun. The Beacon and the Cygnet have two 64-pdrs. each, the cost of discharging which was 18s. per round per gun. The Penelope carries three 40-pdrs. and the Bittern two 40-pdrs., the cost of discharging which was 12s. per round per gun. In addition to this there is a sum to be calculated for the firing of the smaller armaments of the Cygnet, Condor, and Decoy.

The Telegraph in Egypt.—Electric lights of great power were successfully employed on board the Alexandra and other war vessels before Alexandria, for the purpose of searching the harbor and descrying the operations carried on in the fort during the night-time. In anticipation of the bombardment, the Eastern Telegraph Company buoyed the cable a few miles distance from the harbor, ready to be picked up and worked at any moment. On the 9th of July, clerks were transferred to the telegraph ship Chiltern, from which communication with Europe was speedily established. Between her and the fleet intercourse was then kept up by despatch-boats. On the 10th, the Chiltern picked up the Cyprus cable, leaving the Malta cable on board H. M. S. Helicon. The work of grappling was carried out in a most efficient manner. The *Times* correspondent says: "The Chiltern signalled at 7 o'clock that she had grappled the Cyprus cable. She will next splice it on to the cable which is now attached to the Helicon. The Chiltern is lying about three miles to the westward of the Helicon, and will, perhaps, join the cable before daylight. The Helicon will then proceed to the squadron lying off the forts to take orders and repeat signals. From the time the Chiltern left her anchorage in the harbor to the time the cable was grappled barely two hours elapsed. Communication was resumed immediately on the cable being got on board."

During the bombardment of the forts on the 11th July, the Chiltern was moored about four miles distance, having on board the

cables communicating with Malta and Cyprus. From this ship the Admiral's secretary transmitted intelligence to the government in London, throughout the day and evening. This was kept up with all the frequency and speed possible. The arrangements made by the Eastern Telegraph company to meet these contingencies of war received the highest approval of the government, which was enabled, as it were, to witness the operations. The daily press also speak in the highest terms of the admirable manner in which the telegraphic service between Alexandria and London was maintained. "It deserves to be mentioned," says the *Standard*, of the 12th July, "that the telegram which we published in our second edition yesterday morning, announcing the commencement of the bombardment, was despatched from Her Majesty's ship Invincible at 40 minutes past 7 A. M., was received in London at 5 minutes past 6 A. M. (the difference in the time between Alexandria and London being as nearly as may be two hours), so that the message reached this office in about 35 minutes from the time it was despatched from Alexandria. The verbal accuracy, too, with which messages are transmitted deserves the highest praise." The *Times* correspondent also speaks in the highest terms of the company's staff.

Due precautions were taken for the protection of the Chiltern and her valuable charge. Admiral Seymour ordered a war-ship to cruise round her during the night-time. Intercourse between the Chiltern and the fleet was maintained by means of maritime signalling, the electric light serving this purpose by night. Telephonic communication was also established between the Helicon and the British Consulate. Admiral Seymour in a despatch to the Admiralty says that it proved of the utmost value to him, keeping him constantly informed of the state of affairs generally, and inspiring the English residents in Alexandria with a certain amount of confidence. In default of this ready means of communication, it would have been impossible for some hours to have gained any information from the town, except by special messengers at imminent risk of life.

The C Troop Royal Engineer Train formed the field telegraph corps. It consisted of 6 officers, 180 engineers and 64 horses. This troop was provided with six wire-carts with reels on which the telegraph cable was wound, and two covered wagons, which formed the offices, being affixed at each end of the wire for the receipt and despatch of telegrams. The poles, of which there were ten thousand, were rather slender, were painted in conspicuous rings of black and white, and were shod with iron, so as to be easily planted in the

ground. For several reasons, an overhead telegraph was preferred to any other, and for a temporary use, which can be easily removed from place to place, is regarded as especially advantageous. The supply of wire being virtually unlimited, the telegraph could be extended to 250 miles. As yet there is no positive evidence in the current literature of the war that this corps was used during the campaign. Its object was to keep the headquarters of the general commanding in constant communication with the front.

Shelter Carts.—In consequence of the success of the armored train used in Egypt, a number of bullet-proof military carriages are constructing at Woolwich, called "shelter carts," which are destined to be extensively used in future wars. They are similar in appearance to the French carts, and can be used for carrying entrenchment tools for infantry going into action. On arriving at the front they can be dismounted in less than a minute. The iron plates composing the sides are pierced with holes for rifles, so that infantry inside can keep up a constant fire at the enemy, whilst another party of soldiers are at work behind the shelter carts, throwing up earthworks.

Intelligence Department.—The English government, taking a lesson from continental powers, has established an Intelligence Department at the Horse Guards for the army and one at the Admiralty for the navy. These departments are charged with the collection and classification of information from all parts of the world which, in war time, might prove of service to those directing or carrying on active operations. In February, 1882, complete plans of Alexandria and its surroundings were prepared, showing the class, location, command, range and circle of fire of every gun mounted or probably to be mounted, all magazines, war stores, barracks, torpedo works, landing places, railroads, &c. These plans were reproduced and a copy furnished to the commanding officer of each vessel at the time that active operations were decided upon, and were of the greatest utility in the subsequent events. As soon as war was imminent a regular intelligence staff was organized and attached to the headquarters, and 5000 war-maps were supplied to the forces for the use of all officers and non-commissioned officers.

General Organization of the Transport Service.

The transport system forms part of the civil service of the Admiralty—being administered by the "Department of the Director of Transports," which consists at present of the following personnel:

A Director-General of Transports, Admiral Sir William R. Mends, R. N., K. C. B.

An Assistant Director-General, 3 senior clerks, 3 clerks, 6 lower division clerks, and 1 copyist; all civilians.

A Consulting Officer for the Indian Troop Service, Captain C. J. Crittenden, I. N.

A Surveyor of Shipping, Captain W. A. De V. Brownlow, C. B.

An Inspector of Shipping, Mr. Robert Pickard Carpenter, R. N.

List of Officers charged with the superintendence of Transport duties in Great Britain:

River Thames—the Surveyor of Shipping Transport Department; Admiralty.

Bristol—the Officer Commanding H. M. S. Daedalus.

Devonport—the Rear-Admiral Superintendent.

Dover—the Officer superintending the Packet service.

Dublin—the Inspecting Commander of Coast Guard, Kingstown.

Liverpool—the District Paymaster of Coast Guard.

Pembroke—Captain Superintendent.

Portsmouth—the Rear-Admiral Superintendent.

Queenstown (Haulbowline)—the Naval Storekeeper.

Southampton—the District Paymaster of Coast Guard.

At all other places the Coast Guard officer at the station will act.

Transport duties abroad will be conducted by the Senior Commissariat officer where there is no naval officer.

A survey of all merchant ships which may be supposed fitted for such service is made by officers detailed for the purpose, and a record of the results is kept at the office of the Director; this survey details all the characteristics of the ship, the minutest characteristics being set down in the printed form used, so that every ship fitted for transport duty is known in the event of war. When necessity arises proposals are sent to the various owners: the acceptance of the bid is then made subject to conditions mentioned, and the printed "Regulations for Her Majesty's Transport Service," the "Instructions for Masters of Transports," and "Instructions for Transport Officers." A staff of officers, two naval officers, two army officers and two army surgeons, are sent to examine the ship as to hull, machinery, water-tight compartments, &c. Great stress is laid upon the latter being sufficient to enable the ship to float in case any one compartment is bilged.

Besides the list of vessels available for transport duty, a list is kept

at the Admiralty, by the controller of the navy, of those vessels which, having stouter decks, better water-tight compartments, and cellular water bottoms, are adapted for transformation into light cruisers.

There are five Indian troop-ships in service, of 6211 tons, the Crocodile, Jumna, Euphrates, Malabar, and Serapis. These, with the Himalaya of 4690 tons, troop-ship for general purposes, answer the usual needs of the government.

Sixty-three transports, varying from 6000 to 1500 tons, were chartered for the conveyance of troops and stores to Egypt. These were at once taken in hand by the Admiralty on the acceptance of the bid and changed to suit their purposes. At the expiration of the charter they were transferred to the owners in the condition the government had placed them; it being found that serious difficulties were occasioned by attempting to replace them in their original condition before charter.

Naval officers may or may not be placed on board in charge, but when two or more are in company, it is usual for a naval officer to go in one. The masters of the transports are in everything subject to his authority. This officer and the master are governed by the regulations before mentioned.

The general excellence of the present management has been shown in the dispatch of the forces sent to Egypt, there having been no hitch or delay in any of the arrangements made by the Admiralty. Only one hospital ship (the Carthage, a new 6000-ton ship of the P. and O. line) was sent, all others were troop or store transports.

One marked cause of the dispatch was the fact that stalls for the conveyance of horses, made in sections, had been prepared, and 8000 were kept in store ready for service. This was due to the foresight of the present able Director, who has also caused the plan of carrying bodies of troops with all the horses, equipments, &c., belonging to them in the same vessel.

The following terms have been adopted for the transport service:

"*Transport.*"—A ship wholly engaged for the government service, on monthly hire, or a ship wholly engaged by government to execute a special troop or convict service; though not hired by the month.

"*Troop freight-ship.*"—A ship not wholly engaged by government, but performing a voyage with or without a mercantile cargo or passengers, in which conveyance may be engaged by government for troops.

"*Store freight-ship.*"—A ship wholly or partially loaded with government stores or freight.

"*Stores.*"—Stores, provisions, and all articles shipped on government account.

Time Table.

First event—Bombardment of Alexandria, July 11th, 1882.
* Last event—Battle of Tel-el-Kebir, September 13th, 1882.
Interval, two months and two days.

Comparative Time Table.

Bombardment of Fort Sumter, April 13th, 1861.
† Battle of Bull Run, July 21st, 1861.
Interval, three months and nine days.

Distance Table.

From Southampton, England, to	Alexandria, Egypt, .	2960 miles.
" " "	Port Saïd, ...	3115
" India to	Suez Canal, ...	3420
" Malta to	Alexandria, ...	800
" Alexandria to	Port Saïd, ...	155
" Port Saïd to	Suez Canal, ...	99
" Cairo to	Suez (by rail), . . .	145
" Alexandria to	Cairo (by rail), . . .	135

Comparative Distance Table.

From Southampton to New York, ...	3518	miles.
" Bermuda " "	690	"
" Halifax " "	580	"
" Esquimante to San Francisco, ...	700	"

* Success due to efficiency of preparation.
† Failure due to want of preparation.

DETAILS IN REGARD TO THE TRANSPORT SERVICE FOR EGYPT.

The movement of the troops commenced with the despatch in June, 1882, of 800 marines in Her Majesty's ships Orontes and Tamar, to reinforce the fleet lying at Alexandria, which was followed by the transfer (mostly in Her Majesty's ships of war and troop-ships) of nine battalions of infantry, four batteries of Royal Artillery, and one company of Royal Engineers, from the garrisons at Malta, Gibraltar, and Cyprus, amounting to 7700 men and 300 horses and mules; but it was not until it was decided, on July 20, to make up the strength of the troops in Egypt to that of an army corps of two divisions, that the work of war transport fairly commenced. The number of troops to be moved from the United Kingdom to Egypt to bring up the army to the required strength was about 780 officers, 60 warrant officers, 15,500 men, and 5500 horses; and the problem to be worked out was not merely to obtain the number of ships necessary to convey these; it was essential that each fighting unit should be complete with its horses, wagons, equipments and stores, ready to take the field immediately on landing, and that there should be no intermixture in one ship of the component parts of two divisions.

Advertisements for tenders were issued on July 20, and within the next few days, 44 steamships of an aggregate tonnage of 143,800 tons were engaged, varying in size from 5385 to 1240 tons gross measurement, 37 of which were required to carry horses between decks, in numbers ranging from 37 to 286.

They were all fitted and ventilated according to the government specifications, the larger number in London, and the rest in Liverpool or Glasgow, under the immediate supervision of the surveying staff of the Transport Department, temporarily supplemented for the purpose by three captains R. N., five lieutenants, and ten warrant officers. They were supplied from the royal victualling yards with the tanks, provisions and bedding required for the voyage; their compasses were inspected and, if necessary, adjusted by the Admiralty Surveyor of Compasses, and in most cases their crews were medically examined by the naval medical officer. Finally, in every case, when the ship was ready to receive troops, a minute inspection of all the arrangements for the conveyance of the men was made by a special committee of naval, military, and medical officers. The embarkations

took place in London, Liverpool, Southampton, Portsmouth, and Ireland, in many cases simultaneously; a second inspection by a joint committee being made after the troops were on board. The first transport which left England, viz. the Orient, sailed from the Thames on July 30, the others following in rapid succession. The larger number were despatched within eleven days after, and the whole had left by August 19.

Among the transports to which marked attention was devoted was the Carthage, which took out a staff of medical officers, a detachment of the Army Hospital Corps and field hospitals, and was specially fitted to the requirements of the Army Medical Department as a hospital ship, with wards for surgical cases as well as for the sick. No effort was spared to secure in her arrangements the comfort and welfare of the sufferers, and with the possible exception of Her Majesty's ship Victor Emanuel, which was similarly fitted during the Ashantee war, it may safely be said that a vessel more perfectly adapted for its purpose never left England. The Courland was also appropriated as a hospital tender, both vessels flying the red cross of the Geneva Convention, and being prohibited from carrying combatants. The following were the arrangements made by the Carthage for the treatment of the sick: Messing for all government officers embarked was provided by the Peninsular and Oriental Company and paid for by the Admiralty. The company undertook to provide the whole of the victualling on board the ship at fixed agreed rates for each of the following description of rations: Troop victualling as per transport regulations, including one pint of porter per diem, and hospital rations as per fixed diet-table. The rates, including every expense except mess utensils and certificates, were furnished to the master from time to time, by the medical officer in charge of the number of rations of each description issued. The government undertook that, if required, the several army and navy contractors in Egypt should supply the Carthage with provisions, &c., at contract prices. All supplies to officers and men on hospital diet beyond the quantities specified in the diet-table, and all drinks supplied to them, were to be paid for by the Admiralty upon the production of the receipt for the articles received, signed by the medical officer in charge. The purser of the ship was furnished at 6 P. M. each day by the medical officer with a return of the number of each description of diet to be issued on the following day, and men received on board between the times when the returns were made, were dieted on a

special scale. All of the arrangements for the care of the sick and wounded were under the direction of the medical officer in charge, whose wishes it was directed should be followed by the master, and the medical officer in charge was considered as the military commanding officer under the transport regulations.

For the transport of the large quantities of provisions, railway stock, ammunition, and general stores required for the operations of the war and for the maintenance of so large a force in the field, fifteen steamships (tonnage 17,300 tons in all) were chartered, in addition to considerable quantities of material being conveyed under agreement for the voyage, and the stock was accumulated as a reserve at Malta. Six of these storeships (7200 tons) were appropriated for railway stock. The total quantity of stores conveyed up to September 20 was 40,900 tons. Three ships (7500 tons) were specially engaged and fitted for the conveyance of mules, one being detailed to bring up a large number from Natal, and the other being employed in bringing animals to the base from different ports in the Mediterranean. Besides these, several other transports, after landing their troops, were told off for similar service. Two ships (3800 tons) were fitted and sent out from England, in charge of engineers belonging to the Royal Navy, as condensing and tank vessels, in addition to Her Majesty's ships and other transports used for this purpose.

After the dispatch of the two divisions of the army corps, additional troops were sent out to Egypt, consisting of infantry depots and drafts, numbering 60 officers and 2300 men; and to Cyprus three infantry depots and a detachment of Royal Engineers, numbering in all 20 officers and 550 men. Another transport was engaged to take a portion of these troops and the horses, the rest proceeding in Her Majesty's troop-ship and in packets. This raised the total tonnage of transports engaged for the conveyance of troops and horses to about 147,700 tons. An additional force of about 1000 men of the Royal Marines and Royal Marine Artillery was conveyed from England, and 100 of the Malta Fencibles from Malta to Egypt. The troops which were withdrawn from Gibraltar and Malta were replaced by troops from England, four battalions having been sent to Gibraltar and two to Malta, together with four batteries of Royal Artillery.

In view of the responsible and arduous work which the landing of so large a force in an enemy's country must entail, and the necessity for the control of the transports by centralized authority, a captain of the Royal Navy was appointed as principal transport officer to take

charge of the whole duty, with the requisite staff of executive and professional officers to assist him, and Her Majesty's ship Thalia was commissioned as his headquarters, with a special crew adapted for forming working parties. The Thalia was fitted with an electric search light to enable work to be continued at night, and to meet the requirements of the service. Six tugs were chartered, two in England and the rest locally, for towing purposes; and four lighters were purchased. In order to carry out the landing and embarking of cavalry, 15 horse-boats and 17 horse-flats were sent out with the force. Before the expeditionary force was despatched it became necessary to remove refugees from Alexandria to Malta; for this purpose four ships (9200 tons) were chartered on the spot in June, and on the completion of this service they were employed locally for the conveyance of troops, stores and coal for the Mediterranean Fleet. The total number of ships, exclusive of tugs engaged on time charter for the above-mentioned services, was 69, with a total tonnage of 185,000 tons.

The Indian contingent, consisting of 200 officers, 7200 men, 7500 followers and 7300 horses, mules and ponies, was conveyed from Bombay in one Indian government ship, 51 transports and three steam packets. The arrangements for transport of this force were made in India.

TROOPS TRANSPORTED TO EGYPT.—HEADQUARTERS AND STAFF OF CORPS, DIVISIONS, BRIGADES, &c.

General Sir Garnet Wolseley, Commander-in-Chief.

Lieutenant-General G. H. S. Willis, commanding 1st Division.

Lieutenant-General Sir E. B. Hamley, commanding 2d Division.

General officers, 14; colonels, 25; majors, 33; captains, 26; subalterns, 2.

1st Brigade Infantry.

H. R. H. The Duke of Connaught, Commanding.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
2d Battalion Grenadier Guards	1	5	4	20	1	761	51
2d " Coldstream "	1	5	4	20	1	761	51
1st " Scots "	1	5	4	20	1	767	51
Total	3	15	12	60	3	2289	153

2D BRIGADE INFANTRY.

Major-General G. Graham, V. C., C. B., Commanding.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
2d Battalion Royal Irish . .	2	3	5	20	1	761	51
1st " West Kent . .	2	4	4	20	1	861	51
2d " York & Lancast'r	2	3	5	20	1	761	51
1st " Royal Irish Fusiliers . . .	2	3	5	20	1	761	51
Total	8	13	19	80	4	3144	204

3D BRIGADE INFANTRY.

Sir A. Alison, K. C. B., Commanding.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
1st Battalion Royal Highlanders . .	2	4	5	20	1	767	51
2d " Highland Light Infantry . .	2	4	5	20	1	767	51
1st " Gordon Highlanders . .	2	4	5	20	1	767	51
1st " Cameron "	2	4	5	20	1	767	51
Total	8	16	20	80	4	3068	204

4TH BRIGADE INFANTRY.

Sir E. Wood, K. C. B., Commanding.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
1st Battalion Berkshire Regiment. . . .	2	4	5	20	1	861	51
1st " South Staffordshire. . . .	2	4	5	20	1	861	51
1st " ShropshireLight Infantry. . .	2	4	5	20	1	861	51
1st " SussexRegiment	2	4	5	20	1	792	51
Total	8	16	20	80	4	3375	204

Divisional Infantry.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
1st Division 2d Battalion Duke of Cornwall's Light Infantry.	2	4	4	20	1	861	51
2d Division 2d Battalion King's Royal Rifle Corps	2	4	4	20	1	961	51
Total	4	8	8	40	2	1822	102

Cavalry Brigade.

Major-General Drury-Lowe, Commanding.

	Colonels.	Majors.	Captains.	Subalterns.	Warrant Officers.	Men.	Horses.
3 Squadrons Household Cavalry.	2	3	3	16	1	452	431
4th Dragoon Guards	2	3	5	21	1	573	526
7th " "	2	3	5	21	1	573	526
Total.	6	9	13	58	3	1598	1483

	Officers.	Warrant Officers.	Men.	Guns.	Horses.
N. Battery A. Brigade R. H. A.	7	...	175	6	176
½ Bearer Company.	...	.	71	...	...
17th Company Commissariat and Transport.	2	2	178	...	...
Postal Department.	...	...	2	...	...

Divisional Cavalry.

	Men.	Horses.
1st Division, 2 squadrons 19th Hussars.	287	267
2d " 1 " " "	287	267
Total.	574	534

Divisional Artillery.

	Officers.	Men.	Guns.	Horses.
1st Division A. Battery, 1st Brigade R. A.	7	194	6	153
D. " " " "	7	194	6	153
2d Division I. " 2d " "	7	194	6	153
N. " " " "	7	194	6	153
Total.	28	776	24	612

Corps Artillery.

Chief of Artillery Colonel Goodenough, R. A., Commanding.

G. Battery B. Brigade R. H. A.	7	175	6	153
C. " 3d " R. A.	7	168	6	153
I. " " " "	7	168	6	153
F. " 1st " "	7	178	...	207*
	28	689	18	666

Siege Train.

	Officers.	Men.	Guns.
4th Battery London Division R. A.	4	138	54
5th " " " "	4	138	
5th " Scottish " "	4	138	
6th " " " "	4	138	
Malta Fencible Artillery.	4	120	
Total.	20	672	54

Engineer Troops.

Chief of Engineers Colonel Nugent, B. B., Commanding.

Name of Troop.	Officers.	Men.	Remarks.
24th Company.	6	185	For duty with 1st Division.
26th "	6	185	For duty with 2d Division.
8th "	5	103	Corps of Engineers.
17th "	4	85	" " "
18th "	6	99	" " "
Pontoon Train.	7	194	Horses 61—10 pontoon wagons; tonnage of pontoon train 470 tons.
Telegraph Troop (C. Troop R. E)	5	184	12 telegraph wagons; tonnage of telegraph troop 400 tons.
Field Park.	1	33	1 printing wagon.
Railway Staff	4	85	
Ordnance Department	10	150	
Total.	54	1303	

* Ammunition reserve.

COMMISSARIAT AND TRANSPORT.

			Officers.	Men.	Horses.
1st Division	11th Company.		3	208	154
2d "	12th "		3	211	154
Corps	15th "		1	150	201
"	8th "		2	238	272
"	2d "	(auxiliary)	2	43	...
"	7th "		2	43	...
"	10th "		2	86	26
Total.			15	979	807

For each brigade 7 muleteers and 7 mules.

HOSPITAL SERVICE.

	Officers.	Men.
1st Division 2 Field Hospitals.	12	90
½ Bearer Company	6	71
Total.	18	161

2 ambulances for advanced base.

	Officers.	Men.
2d Division 2 Field Hospitals.	12	90
½ Bearer Company.	6	71
Total.	18	161

2 ambulances for advanced base.

CORPS.

	Officers.	Men.
4 Hospital Corps.	32	180

Veterinary surgeons, besides those in cavalry, 4 in each division and 10 for general service.

Postal service for each division, one for headquarters, and one for the base with 22 men.

POLICE FORCE.

	Officers.	Men.
Mounted Military Force.	2	73
Foot " "	2	65
Total.	4	138

GARRISON OF ALEXANDRIA.

	Officers.	Warrant Officers.	Men.
2d Battalion Manchester Regiment.	30	1	750
2d " Derbyshire "	30	1	750
Malta Fencible Artillery.	4	...	120
Total	64	2	1620

Totals.

Officers and Men.

General Officers	14
Colonels	73
Majors	176
Captains	235
Subalterns	601
Warrant Officers	88
Men	22,802
Total	23,989

Horses.

Officers'	768
Troop	2303
Draught	2563
Pack	503
Total	6137

Carts and Wagons.

Water Carts	111
Two-wheeled Carts	776
Four " "	23
Small Arm Ammunition Wagons	47
Forge Wagons or Carts	38
Guns and Gun Carriages	58
Ammunition Wagons	55
Ammunition and Store Wagons	25
Total	1133

Division of Troops from India.

Major-General Sir H. T. Macpherson, K. C. B., Commanding.

	Officers.	Men.	Remarks.
1st Battalion Seaforth Highlanders	21	740	
1st " Manchester Regiment	21	750	
7th Bengal Native Infantry	8	680	
20th " " "	8	680	Half Sikhs, half Pathans (Mahommedans).
20th " " "	8	680	One-third Mahommedans from Bombay, two-thirds Panjabees & border Mahommedans.
Followers	...	3500	
	66	7030	

CAVALRY.

	Officers.	Men.	Remarks.
2d Bengal Cavalry	8	500	One-third Sikhs, one-third Rajputs, and one-third Hindustani Mohammedans.
6th " "	8	500	One-third Sikhs, one-third Brahims and Rajputs, and one-third Hindustani Mohammedans.
13th " "	8	500	One-half Sikhs, one-half Panjabee and Frontier Mohammedans.
Total.	24	1500	

ARTILLERY.

	Officers.	Men.
9-pdr. Battery	6	157
7-1 Garrison Mounted Battery	6	106
Total	12	263

ENGINEERS.

4 companies Madras Engineers—12 officers, 400 men.

GRAND TOTALS.

19,229 Infantry.
3818 Cavalry.
1927 Artillery.
1278 Engineers.

Making with all other branches of the military service 31,468 men.

MATERIAL TRANSPORTED TO EGYPT.

The equipment of the different corps composing the force varies in some important particulars from that which has been laid down by recent regulations. The most notable of these changes consists in the formation of a regimental transport, in which light two-wheeled carts and pack-saddles replaced the usual service equipment; in the substitution of double tents in place of the ordinary single bell-tents; in a greatly extended distribution of revolvers in arming the drivers of the regimental transport of the Royal Artillery, and of the Commissariat

and Transport Corps; in the supply of cart in place of wagon transport generally; in the substitution of the new 13-pounder muzzle-loading rifled gun in the place of 9-pounder 6-cwt. gun; in the formation of special corps, viz. the signalling corps, the post-office corps, the railway corps, and the corps of mounted infantry. Again, in the re-equipment of the telegraph troop of the Royal Engineers, and in the employment of the muzzle-loading siege train in its remodelled form.

In the various branches of minor equipment, addition was made by the issue of brown coloring material for helmets and buffs, and by the distribution of goggles and veils, carbine-slings for the cavalry, and eye-fringes for the horses. Besides these, 30,000 suits of grey serge clothing, in addition to the red and blue serge, were sent out. Five thousand maps of Egypt, in the corrected form as drawn by the Intelligence Department, were also given to those who required them.

The details of the equipment of each corps differed in many respects from that which is laid down by regulation, this variation having been rendered necessary by the peculiar character of the country in which the army was serving. In the cavalry the regimental transport of the Household Corps consisted of two cavalry spring supply-carts, in addition to the peace establishment of four carts, one ammunition cart, one forge wagon, two water-carts, and twelve draught horses sent from the Royal Artillery. In the other cavalry regiments it was not necessary to send horses from the artillery for transport purposes.

The camp equipment of each cavalry regiment was eight 4½ lb. felling-axes, about 115 camp-kettles of the Flanders or Terrens pattern, with canvas bags. This is at the rate of one per five men. One blanket per man, two boxes for stationery, 81 canvas buckets, and 10 leather buckets, 9 handled bill hooks and 64 reaping hooks, 10 globular brass lanterns, with 10 quarts of colza oil, the latter to be supplied by the commissariat. The stable equipment consisted of 540 white forage cords of 21 feet length, 540 waterproof saddle-covers, 64 wooded heel peg-mallets, 17 wooded helved mauls, 540 heel-rope pegs, 165 2½ feet picket posts, 540 tarred head-ropes, with rings and the same number of double-shackled tarred heel-ropes, 42 3-inch picket-ropes 25 yards long, and 37 5-bushel jute corn-sacks. Of intrenching tools there were eight 6½ lb. pickaxes, one iron crowbar, 4 feet 6 inches long, and 32 helved spades. The spare harness materials supplied according to the scale laid down by the equipment regulation with one set of collar maker's and saddler's tools, four sets

of saddler's tools, one set of saddletree maker's tools, remained at the base. Nine carriage brushes, 61 lbs. of grease, half a quart of linseed oil, four quarts of rape or sweet oil, were also supplied. The ordnance stores consisted of nineteen tin boxes of grease, 10,080 rounds of Martini-Henry carbine ammunition, and 1200 rounds of revolver ammunition, one spare linch-peg for the ammunition cart, six for the two-wheeled wagon, and one for the forge wagon, one pair of light drag ropes, and nine lashing ropes, one spare washer for ammunition cart, one for two-wheeled wagon, and six for the forge wagon. The special accoutrements served out were bandages, calico, and lint, one set per man of every rank, and the materials for the repair of accoutrements, according to regulation, to remain at the base. A part of the materials for the repair of arms were also to remain at the base with the armorer's field-forge and the carpenter's equipment. The miscellaneous equipment consisted of one set of signalling implements, one set of tools for opening packages, one set of tools pertaining to small arms, four sets of farrier's and shoeing-smith's tools, two chests of veterinary appliances, eight pairs of handcuffs, one set of butchery implements, one tarpaulin for each cart, ten staff sergeant's kits, and veterinary stores as laid down by the equipment regulations, the latter to be taken if possible.

The camp equipment of the second line was 526 horse-blankets, with pads and surcingles, 526 forage-nets. Tents at the rate of one tent per ten men, with officers' tents according to regulation. Filters were supplied at the rate of 15 to every 100 men, and revolvers to the non-commissioned officers and transport drivers.

The Field Artillery with the Army Corps consisted of N battery, A brigade, of the Royal Horse Artillery, serving with the Cavalry brigade, and armed with the 13-pounder gun; A battery, 1st brigade, and D battery, 1st brigade, with the 1st Division; and I battery, 2d brigade, and N battery, 2d brigade, with the 2d Division. All these four were armed with the 16-pounder. In the Corps Artillery, armed with the 13-pounder, were G battery, B brigade of the Royal Horse Artillery; C battery, 3d brigade, and J battery, 3d brigade of the Royal Artillery. The equipment of each battery was as follows: six guns and gun-carriages with limbers and ammunition wagons, one ammunition and store wagon, one store limber wagon, one forge wagon, one water cart, and one cavalry spring supply-cart. The C battery, 3d brigade (13-pounder) was equipped with long trail guns, carriages, and special pattern ammunition wagons, in which the pro-

jectiles were carried vertically in top-lid boxes. Each battery of the Royal Horse Artillery and the 13-pounder batteries of the Royal Artillery carried with them 180 common shell, 648 shrapnel, 24 case-shot, and, in addition, the Ordnance Department had for each battery 200 common shell, 720 shrapnel, and 28 case-shot. This made a total of 300 rounds per gun. Each 16-pounder battery carried with it 144 common shell, 432 shrapnel, and 24 case-shot, and the Ordnance Department had charge of an extra 288 common shell, 864 shrapnel, and 48 case-shot, making in all a total of 300 rounds per gun.

Eight hundred incendiary stars were carried with each battery—13-pounder and 16-pounder—and the necessary instructions for filling common shell with stars were supplied to the batteries. Each battery had twelve carbines and revolvers, the latter being for the use of the staff-sergeants, trumpeters, and drivers. Thirty rounds per carbine and thirty-six per revolver were carried, and the Ordnance Department had seventy and sixty-four rounds respectively in reserve. A new pattern equipment for carrying stores for disabling guns was prepared, and sent out to the Royal Horse Artillery batteries to replace the old patterns. The batteries had the war equipment, in accordance with regulations, including fifteen per cent. of filters, and like the rest of the force, were provided with double tents. The two Royal Horse Artillery batteries were each furnished with twelve extra pairs of traces for breast harness, making thirty-six per battery, and each Royal Horse Artillery and Royal Artillery battery was supplied with one additional set of new-patterned breast harness, as a sample, to enable the batteries to alter the old-pattern breast harness in possession as opportunity offered. Mark IV. Watkins field range-finders were provided, together with old-pattern clinometers to each battery. Hand-books, including one for range-finder, and India-rubber range tables and Price's grease for wheels, especially suitable for hot climates, were given out. Eye-fringes for horses were also issued prior to embarkation.

The Ammunition Column (F battery, 1st brigade, Royal Artillery) took in their equipment two spare gun-carriages, limbers, and ammunition wagons for the 13 and 16-pounders, with 284 rounds for the former and 200 rounds for the latter; four ammunition and store wagons, carrying 504 rounds, 16-pounder, packed in boxes suitable for pack transport in the usual proportions; 38 carts Martini-Henry rifle ammunition (364,000 rounds), four carts carbine ammunition (40,320 rounds), one forge wagon, one ammunition and store wagon

for carrying tools, one water-cart, one supply-cart (cavalry spring). Each of the above-mentioned 42 carts carried three boxes of Adams pistol ammunition (30,240 rounds) and two boxes of Enfield pistol ammunition (20,160 rounds). Sixteen thousand incendiary stars were carried with the column, and it was supplied with 56 carbines and 112 Enfield revolvers, and it had the war equipment of the other batteries.

The batteries of garrison artillery detailed for the siege train were from the London Division—1st battery, 1st brigade; 4th battery, 1st brigade; 5th battery, 1st brigade; and from the Scottish Division, 5th battery, 1st brigade; and 6th battery, 1st brigade. All these were provided with the special war equipment. The 1st battery, London Division, embarked with one water-cart, three supply-carts, and four sets of wheel harness. Water and supply-carts were furnished for the other batteries from Malta. The siege train had with it the 40-pounder, the 25-pounder, and the 7-pounder guns, with their carriages and platforms. It had also the 6.3-inch howitzers. Two hundred rounds of ammunition per gun were supplied, and 100 old-pattern and 100 new-pattern star shells for each of the howitzers. Ten new-pattern clinometers, and two Nolan's field range-finders were provided.

The following guns could be landed from the fleet if necessary: Three 40-pounder rifle muzzle-loaders on wooden slides, and three 40-pounder rifle muzzle-loaders on wooden common carriages, twenty-seven 9-pounders, four 7-pounders, and twenty-five 0.45-inch Gatlings, all on travelling carriages.

There were of the Light Unit siege train ten 40-pounders, four 25-pounders, and six 7-pounders, at Malta; and six 25-pounders at Alexandria. Four 40-pounders were taken to Alexandria by the 4th battery, 1st brigade, of the London Division, and two 40-pounders and six 12-pounders were taken by the 5th battery of the 1st brigade of the London Division.

The regimental transport of each infantry battalion consisted of 10 two-wheeled carts, 2 water-carts, 21 pack-saddles, with line gear, and 26 horses. Pocket filters were supplied in the proportion of 15 to every 100 men, and the helmets were colored with raw umber. In the camp equipment of each infantry battalion there was one tent for each ten men, and all those that were served out were thick double bell-tents. Of axes there were ten for felling, each weighing 4½ lbs., and sixteen hand-axes weighing 2 lbs. The number of axes given out was considerably below what is usual on such occasions, but this,

no doubt, was owing to the peculiarity of the country in which the army was serving. Blankets were served out at the rate of one per man. They were of ordinary gray description, and were of good useful quality. The spare blankets were not to be carried by the battalions themselves as laid down by the ordinary regulations. Such extra ones as were required were to be drawn from the commissariat. Of buckets there were thirty-two canvas and twelve leather; this again was less than usual. The stationery boxes were two in number, instead of three. According to the regulations, fifty bill-hooks are served out to an infantry battalion on active service; on this occasion twenty only were given; however, no reduction was made in the number of reaping-hooks, which is five. Camp-kettles, with bags and straps, were given at the rate of one per five men; and two brass globular lanterns were served out to each battalion, the oil for which was drawn as usual from the commissariat. Of forage cords there were 58, and the same number of waterproof saddle-cloths, picket-pegs, and head ropes with rings, and heel ropes with two shackles each. There were also eight picket-peg mallets and six white picket ropes, each 16 yards long. Among the other stable necessities in each infantry battalion were 20 two-bushel corn bags and 58 nose bags, 13 harness brushes and 29 horse brushes, with the same number of currycombs, 14 hoof-pickers and turn-screws for the drivers and the transport sergeant, 13 trimming scissors, 34 water sponges, 12 carriage water brushes, 30 lbs. of wheel grease, eight quarts of harness oil, 500 horse nails, 12 spare lynch-pins for the regimental two-wheeled carts, four spare shafts, 12 iron drag-washers for the two-wheeled cart, and one tarpaulin for each cart. The materials for the repair of the saddlery were on the scale as laid down by the equipment regulations; these, together with one set of collar-maker's tools, and the spare parts of harness and saddlery, were to remain at the base.

The ordinary intrenching tools served out to each infantry battalion were at the rate of four pickaxes weighing 6½ lbs. each, two iron crowbars, 4 feet 6 inches long, and nine helved spades. The ordnance stores of each regiment, in addition to those already mentioned, consisted of twelve tin boxes of grease, three pairs of light drag ropes and ten lashing ropes, 28,800 rounds of Martini-Henry cartridges, and 720 revolver cartridges. The special accoutrements consisted of one canvas bag for ammunition for each pack animal, bandages, calico, and lint for each man of all ranks in his personal equipments,

and light spare haversacks for each battalion. Three months' supply of materials for repairing the arms and accoutrements, with the armorer-sergeant's field forge and carpenter's establishment, were to remain at the base. Among the miscellaneous stores were one chest of signalling implements, eight ambulance stretchers, two pairs of handcuffs, one chest of butchery implements, one set of package opening tools, twenty-one pack saddles, and eight staff-sergeants' kits. There was provision for thirty officers' baggage. The veterinary stores were on the scale as laid down in the equipment regulations. The camp equipment of the second line was fifty-five horse blankets, with pads and surcingles, thirty-four forage nets and tents at the rate of one tent per ten men, with officers' tents as laid down by regulations. In addition to the above, twenty-nine revolvers were given to the transport drivers in each regiment. And what is, perhaps, of the most importance, 200 Wallace Light Infantry spades, with special instructions as to their carriage, were issued to each infantry battalion.

The scale of clothing and equipment in addition to the regulation kit of the Indian contingent was as follows: For the British troops, each man one water-proof sheet, two jerseys, one pair boots, one putter (on payment), one extra blanket, and one flannel belt. Native troops were to have the same as the British, and the followers also had the same, with the addition of one Lascar, or follower's coat, one great coat, one pyjanah, one tin canteen, and one haversack. The tents supplied from the Grand Arsenal in India to the contingent were 2873, and consisted of one hospital tent, 267 officers' tents, 58 staff-sergeants' tents, 126 British soldiers' tents, 230 Sepoys' tents, 142 Lascar's tents, 1926 mountain service tents, 23 dooly-wallah tents, and 1249 tarpaulins. The total number of small-arm ammunition rounds issued by the Indian Arsenal was 269,960.

We have given above the fullest particulars with regard to the equipment of the force in Egypt, and it may be interesting to give some details as to the commissariat stores which were sent out. These stores were supplied, speaking generally, to the amount that would be required for a period of about two months for 25,000 men. With regard to meat there was a contract for fresh meat, of which three shiploads, at least, arrived at Ismailia. In addition to the fresh meat, and in order that provision might be made for any failure or difficulty in cooking, twenty-five days' supply for 25,000 men of preserved meat was sent out, also a week's supply of frozen meat

for the same number. In order to provide for days when bread could not be baked, thirty days' supply of biscuit was sent. Of groceries, there was three months' supply of tea, coffee, sugar and cheese; sausages and tinned tongues for use as an iron ration were carried by each regiment. Two months' supply of compressed vegetables was sent, and contracts for fresh vegetables were made and were supplied on the spot—a luxury which was not enjoyed by the army in the late Zulu campaign. Large quantities of lime-juice were sent, and tobacco supplied. Disinfectants, such as carbolic acid powders, &c., were also sent. The list of the articles supplied was as follows: Preserved meat, biscuits, flour, malt, hops, baking powder, potatoes, frozen meat, tea, coffee, sugar, salt, pepper, groceries boxes, sugar boxes, compressed vegetables, Erbswurst rations, lime-juice, rum, tobacco, medical comforts in boxes, condensed milk, extractum carnis, arrowroot, Scotch barley, cocoa and milk in tins, brandy, port, essence of beef, soup in tins, Burgundy, claret, champagne, cupralum powder, carbolic acid powder, M'Dougall's powder, sulphur, ale, porter, soap, compressed hay, compressed hay cake, compressed grain cake, oats, compressed forage, candles, tin-openers, cheese, sausage, and tinned tongues.

Native regiments went on the present established strength of 550 natives of all ranks for cavalry and 832 for infantry, so far as they were complete, minus the men who were unfit. Followers, servants, and baggage were according to the Cabul scale, but without grass-cutters. All regiments were completed with all establishments (including commissariat) according to the orders laid down in their respective Presidencies. In the Cabul scale of intrenching tools bill-hooks should be omitted. Spare horses at two per troop were taken with the cavalry. No rezais or padded quilts of any description were allowed to be taken with the cavalry; all were left behind or disposed of. M'Dermott's portable camp filters were supplied to European troops on the scale of four per company or battery; 100 were made up under arrangements by the Quartermaster-General in India. Quartermasters' establishments were supplied under Clauses 15 and 79, Army Circulars of 1880. The families of the British troops left behind in India remained at their stations, and received in addition to subsistence allowance, three-quarter rations for the wives and half rations for the children. The artillery ordnance and ammunition were as follows: For artillery, 500 rounds per gun; for infantry, 500 rounds per rifle, and for cavalry, 300 rounds for

carbine. All the small-arm ammunition came from the Bengal Ordnance Department. No artillery spare mules went beyond those in battery charge; 200 rounds of small-arm ammunition went in regimental charge, and 300 in ordnance charge, the same principle applying to artillery ammunition, except in the case of the mountain battery, which took 100 rounds in regimental charge; 400 rounds were in ordnance charge. With regard to the engineers, the regulations were: No pontoons were to be taken, only bridge superstructure then in store at Poona and Bangalore. Fifty light railway trollies, 4 feet 8½ inches gauge, with broad platforms, were to be constructed and sent with a railway staff of about twenty trained workmen, including some plate layers. Five miles of rails to be sent with fittings complete. The Sapper telegraph train (Bengal) to be taken and used as the military telegraph train for short operations in front. One hundred miles of light telegraph wire, with plant in proportion, to be supplied by the Government Telegraph Department, and establishment to work it. The duty of submarine mining and the removal of obstructions to be intrusted to the Royal Navy. Any additional submarine stores required were to be drawn from the Bombay Ordnance Department. A small engineer field park to be prepared under the proposals of the Commanding Royal Engineer. A large supply of sand bags to be sent. Timber for water-troughs to be taken from Bombay by the Engineer Department.

The clothing and equipment were: Water-proof sheets to be issued for all troops and followers. The Cabul scale of clothing to be adopted for troops, minus the poosteen or mirzai, warm socks, and Balaclava caps and mittens, with the addition of one jersey and one canvas frock. The following scale of clothing to be issued to followers: One blanket, one great coat, one Lascar or follower's coat, one pair light pajamas, one pair native shoes, one tin canteen, one haversack, two banyans or jerseys. Flannel belts to be provided for all troops and followers. Followers were not to be armed. The camp equipage regulation provided that mountain battery tents for European, and Sepoy or Lascar pals for natives, were to be on the Cabul scale; and the commissariat regulations that puckals were to be supplied according to the Cabul scale, the commissariat to have a fair supply in store, and that no bullocks were to be taken, and mules to be supplied for puckals.

The transport regulations were: No carts were to be taken. No extra transport was to be taken from India beyond that required for

regiments, at half Cabul scale, or a total of about 2500 mules, which were to be supplied under arrangements by the Commissary-General, Bengal. The regulations for sea transport were: Every transport should go complete in itself, with the arms, ammunition, baggage, and food of the troops embarking, as well as the transport mules. Water-proof capes to be supplied for the watches on board ship. Weighing machines up to 2 cwt. to be supplied for board ship service. The general regulations were: As soon as the transports were ready, the troops to be railed, with accommodation on the ordinary traffic scale to Bombay, if they could be embarked at once; if not, the troops to halt at Deolali or Poona, for those coming from Madras, or at suitable rest-houses along the road. The railway arrangement to Bombay provided that one railway transport officer should be posted at Allahabad and one at Jubbulpore. Followers, servants, baggage, camp equipage, and kit for staff and departmental officers were on the Cabul scale, but grass-cutters were not taken.

TRANSPORTS.

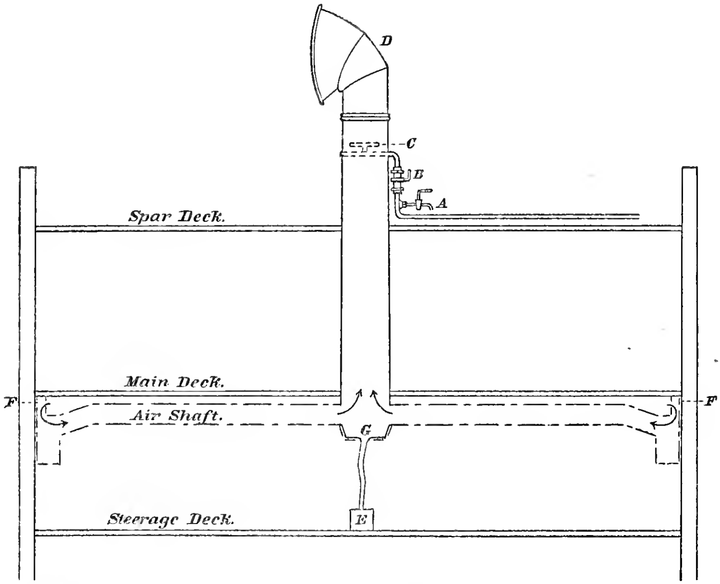
By Lieutenant Albion V. Wadhams, U. S. N.

Transport Officer.—A naval officer is detailed to act as Transport Officer in each port. The captains of the transports report to him on arrival, each morning while in port, and receive their orders from him. At the beginning of each month the captains are furnished by the Transport Officer with a certificate as to the condition of their vessels and conduct of the officers, which is forwarded to the agents of the steamers. Upon this certificate being presented to the Admiralty office, that office pays the agents in advance for one month.

Distinguishing Marks.—All steamers employed by the English Government as transports carry the Naval Reserve flag with a yellow anchor in the fly. They are numbered consecutively, their numbers being painted on each bow and quarter. The steamers from England have black figures on a white ground; those from India have red figures on a white ground.

Sanitary Arrangements.— Dr. Edmonds' system of ventilation has been fitted to all transports carrying men or horses, as an additional means of exhausting foul and distributing fresh air along the lower decks. The system consists of one or more iron ventilators

with movable cowls. The ventilators connect with wooden air shafts which extend fore and aft the steerage decks, just under the main deck, generally close out to the side, sometimes amidships. These shafts have vertical feeders *F*, five or six feet apart, the holes of which are covered with perforated zinc. A steam jet *C*, the pipe of which leads from one of the boilers, is introduced into the ventilators above the spar-deck. To exhaust the foul air, turn the cowl from the wind, open the cock *A*, to allow the water which may have been condensed in the pipe to blow off, then close it and open the cock *B*. The steam escapes through the jet with a low hissing sound, forming a partial vacuum in the ventilator, which draws the foul air into the air-shafts and carries it to the upper deck.



A—Water cock. *B*—Steam cock. *C*—Steam jet. *D*—Movable cowl.
E—Water tank. *F*—Feeder to air shaft. *G*—Water receiver.

Any water that may be condensed in the ventilators is caught in a lead receiver *G*, which is placed under them, and runs into a tank *E*, on the deck below. The steam is turned on the ventilators for half an hour after each meal and for five minutes every hour during the night. In very warm weather it is kept on all the time. After the

foul air is exhausted the cowl is turned to the wind and acts as a common ventilator. I saw the system worked. It exhausted the foul air from the after steerage deck of the Marathon, 2403 tons (Cunard Line), in less than five minutes. It is spoken of very highly by all the captains of the transports that I saw.

The decks on which men are quartered or horses stabled are supplied with fresh air in the usual way by means of windsails and air-scoops. Care is taken to open the air-ports whenever the weather permits, and the scoops with which they are furnished are kept in place. The men are not allowed on the deck on which they are quartered except at night and during meal hours. They sleep in hammocks which are stowed in temporary nettings on the spar-deck. Besides the precautions mentioned under Stable Regulations, great care is taken that the urine does not run into the bilge. It was found that unless this precaution was taken the officers and men quartered near the hatches suffered invariably from chronic sore throat, and that all the horses stabled near them became sick. On the decks where the scuppers lead overboard the urine is allowed to run off through them. On the other decks the scuppers leading to the bilge are carefully plugged, except a few which lead into large tanks, in which the urine is caught and then pumped overboard. The stables are kept thoroughly clean, the stalls being frequently raked out and sprinkled with chloride of lime.

Quarters and Necessary Alterations.—In some of the steamers where the accommodations are not sufficient for the officers, temporary staterooms and saloons are fitted on the after part of the main deck. The men are quartered on the steerage-deck. On board the larger steamers, used for carrying emigrants, the bulkheads on the steerage-decks, separating the men from the women, and all but a few berths were removed. Temporary mess-tables and seats are bolted to the deck, athwart-ships, close out to the side, leaving a midship gangway the whole length of the deck. The few berths that are left in the place are generally at the forward end of the deck near one of the hatches, and are used for the sick. Near them is the temporary dispensary. In a large box amidships the men's sea kits are stowed. About the decks are the arm racks. Temporary store, issuing and orderly rooms, magazine and prison are fitted on the forward steerage deck. In the forward hold is stowed the fodder; in the main hold the provisions, extra water tanks, and carts with wheels off, end boards out and sides folded on the bottoms.

Stables.—The horses are stabled on the main deck. The stalls are placed athwart-ships two feet from the ship's side. They are about two feet wide, made of four-inch scantling for the uprights and one two-inch plank for the ends and sides. They are fitted with leather pads for the ends to prevent chafing, and small galvanized iron mangers. Each stall has a movable floor, the planks of which are about one inch apart, that they may be readily cleaned. A few of the stalls are left vacant that some of the horses may be shifted each day, weather permitting, in order to clean the stalls thoroughly. The horses all stand with their heads inboard. To prevent their being thrown, a wide canvas sling is kept under each horse; the ends of the sling are fastened to the scantlings over the stalls. As soon as a horse shows any signs of fatigue he is triced up so that his feet just touch the deck. Amidships on each deck on which horses are stabled there is a large stall ("loose stall") four times the size of the others, into which a horse is put when sick. Near it is the office and dispensary of the veterinary surgeon.

Stable Regulations.—(1) Daily allowance: water, 8 gals.; oats, 5 lbs.; bran, 5 lbs.; hay, 10 lbs.; carrots, when available; vinegar, ½ gill; nitre, ½ oz.; McDougall's powders, 5 ozs.; chloride of lime, 1 oz.; powdered gypsum, 2 ozs. (This allowance is put on board, but is to be used as the commanding officer directs.) For first few days feed sparingly, bran to form the larger ration. After the horses become more accustomed to the sea, feed more liberally. Feed and water three times a day.

(2) Stable duties: Morning—Rake the stalls well and clean up; water horses; sponge mouth, nostrils, eyes, &c. Feed with hay after watering, and then with oats or bran.

(3) Midday—Shift horses to spare stalls and on deck when practicable. Pick out and wash feet; groom thoroughly. Each stall is to be thoroughly cleaned; water and feed the horses. After dinner feed with hay for an hour.

(4) Evening—Rake and clean stalls; water and feed horses.

Miscellaneous.—The government pays from 16 to 35 shillings per gross ton for the first month, and at a reduced rate for the other months engaged. All alterations and fittings are made at the expense of the government. It also pays for pilotage and harbor dues; it furnishes extra water tanks and hammocks for the men, subsistence for officers, men and horses, pays for all the coal except that which is used in the galley, for running the steam derrick, and for condensing purposes.

The owners are obliged to keep their vessels in repair and ready to move at any moment. The Marathon was fitted for transport service in six days and five nights, working as large a number of men as could work about the decks. She brought out 9 officers, 160 men, and 103 horses. Her crew when on transport service is nearly double what it is at other times, consisting of 51 men and 39 officers, including the petty officers. The government requires the transports to carry three men for every hundred tons for the first thousand tons, and one and a half men for every other hundred tons of tonnage.

The transport system consists of vessels ranging from 329 to over 5000 tons. Three tugs are employed; one, the Recovery, is a working tug, the Maulkins Tower is used for condensing, and the Carthage for a hospital ship. The transport officer at Alexandria informed me that seventy-three or seventy-four steamers were chartered in England and thirty in India. He also stated that all the steamers were carefully inspected by government officers; that those which were high between decks were preferred, but no special care was taken in the selection of steamers except the usual care as to the condition of the vessels.

The *Army and Navy Journal* of Sept. 9th, 1882, contains the following statement: The British army in Egypt consists of 19 infantry battalions of Europeans and 3 battalions of Sepoys, 3 regiments of European and 3 of native cavalry, 2 batteries horse artillery, 7 field batteries, 1 mountain battery, 5 siege batteries and 1 battery of ammunition reserve, 5 companies of Royal Engineers, a pontoon train, a telegraph troop, a field park and 5 companies of Indian sappers; and ordnance, commissariat, and army hospital corps troops. The total strength is: infantry, 19,223; cavalry, 3318; artillery, 1927; engineers, 1278; making up with departmental troops a grand total of 31,468 of all ranks. . . . The whole force was afloat by August 10, and landed in Egypt before the end of the month.

HOSPITAL SERVICE OF ARMY IN EGYPT.—WATER SUPPLY OF ALEXANDRIA.

By Surgeon John W. Coles, U. S. N.

Connected with the army there are eight hospitals, six of which are at Ismailia and Cairo. Of the remaining two, one is at Ramleh,

and the other at Alexandria. The last is situated in the northern part of the city, near the harbor and railway station. The building used is a cotton warehouse, one story high, with a loft, and contains four large, well lighted and ventilated rooms, which will accommodate about 300 patients, giving each some 2000 cubic feet of air space. I saw nothing particularly worth noting in the general arrangement of this hospital. The beds were clean and comfortable, and the patients appeared to have everything required. The diet is the ordinary army ration, supplemented in special cases. All water used in drinking and cooking is condensed. It is the general receiving hospital for this part of Egypt. The sick and wounded, at the front, are taken to the hospital at Ramleh, and from there brought to this one. All cases likely to be protracted are transferred as soon as possible to Malta. At the present time it contains 187 patients, nearly all being medical. The principal diseases are dysentery, ophthalmia, venereal cases, typho-malarial, typhoid and remittent fevers. Owing to the constant movement in the field, and the changes in the hospital, I have not been able to obtain the percentage of sickness or deaths, nor have I been able to get any information regarding the troops at Ismailia and Cairo.

In relation to the water used in Alexandria, I have to state that, excepting some from cisterns, it all comes from the Mahmoudieh canal, which is supplied from the Nile. About a mile from the city it is pumped into a basin or canal, strained through a coarse bag and treated with alum as it passes over. It is again filtered before it enters the pipes for use. The water has been used on board of this ship whenever she has been at Alexandria, and no ill effects have followed. It is soft and clear, and does not contain much organic matter.

SUBSISTENCE OF SOLDIERS, SAILORS AND MARINES IN EGYPT.

By Paymaster Jonathan Q. Barton, U. S. N.

When Alexandria surrendered, about a thousand sailors and marines were sent ashore from the English fleet to take possession of the city and garrison its defenses. These men on leaving the ships carried two days' rations of provisions in their knapsacks. These

rations consisted of hard bread, canned meat, sugar, tea and cocoa. As it became necessary to keep this naval brigade on shore a long time in order to garrison the several posts in and about the city, permanent arrangements for subsisting the men were soon made. A depot of supplies was established on shore. Provisions sufficient to furnish one thousand men with regular rations for one month were sent from the ships to the depot. From this point supplies were forwarded to the several stations, as needed. These articles were delivered in the original packages. The several parties of men were organized into regular messes, cooks being detailed, and other arrangements made in the same manner as on board ship. The mess outfit and cooking utensils were supplied from the ships. The rations issued were exactly the same as those supplied at sea, including the regular allowance of rum. After a time, when it became possible to procure fresh beef and vegetables, these articles were substituted for the regular sea rations five times a week. No modification of the ration was made to suit the climate. Whenever the men were engaged in any specially hard work, or had been subjected to any great fatigues, extra rations of rum or cocoa were served them.

As to the army ration, I have to note that it has been considerably increased since the troops landed. One and a fourth pounds of fresh meat and the same quantity of vegetables, in lieu of one pound, are now issued to the soldiers. The allowance of tea, coffee and sugar has also been increased. Beer is served to the troops instead of rum, this change being recommended by the surgeons as a sanitary measure.

I am informed that the delay of the army in the vicinity of Ismailia, which was generally commented on, was not caused by any lack of commissary supplies. Ample stores of provisions were on board the transport ships in port at the time. But there was not a sufficient number of lighters to be had for the speedy unloading of the ships. In addition to this, great difficulty was found in drawing the loaded carts through the deep sand. Many of the carts used in carrying supplies proved to be too weak for the service required, and when subjected to heavy loads broke down. The delay in forwarding supplies to the army was entirely due to these two causes.

SIR GARNET WOLSELEY'S INSTRUCTIONS.

In the Blue Book on the affairs of Egypt appear the following instructions to Sir Garnet Wolseley. They are dated War Office, the 4th August, and Mr. Childers writes:

"Her Majesty having been graciously pleased to appoint you to the command of the army ordered for service in Egypt, in support of the authority of His Highness the Khedive, as established by the firmans of the Sultan and existing international engagements, to suppress a military revolt in that country, I have received the Queen's directions to instruct you to assume the command of an expeditionary force for that purpose without delay. The force which Her Majesty has placed under your command, proceeding from this country, consists of four regiments of cavalry, eight batteries of Royal Artillery, one ammunition column, six troops and companies of Royal Engineers, and ten battalions of infantry, making a total of 14,794 non-commissioned officers and men of all arms. You will also have under your command a force about to be despatched from India, consisting of three regiments native cavalry, one mountain battery of artillery, two companies of Madras sappers, one British battalion of infantry, and three native battalions of infantry, making a total of 4586 non-commissioned officers and men. Another portion of the force, consisting of four garrison batteries of artillery, two companies Malta Fencible Artillery, one company Royal Engineers, and 6½ battalions of infantry, making a total of 6186 non-commissioned officers and men, to be under your command, has already, as you are aware, proceeded to Egypt, and is now engaged in the protection of Alexandria. Her Majesty's Government do not wish to fetter your discretion as to the particular military operations which may be necessary, but the main object of the expedition is to re-establish the power of the Khedive. Her Majesty's Government empower you, after successful operations against Arabi and those in arms against His Highness the Khedive, to enter into any military convention which the circumstances warrant, but no arrangements involving a political settlement should be made by you. It will be desirable, should time and circumstances admit, that the terms of any convention should be referred to Her Majesty's Government before being finally decided; and in such case they should be simultaneously communicated to Her Majesty's Agent and Consul-General for the information of His Highness the Khedive. You are aware that in the

operations which have taken place at Alexandria, Admiral Sir B. Seymour, in the absence of Her Majesty's Agent and Consul General, has been acting as the representative of her Majesty's Government. Sir Edward Mallet being now about to return, this arrangement will cease upon his arrival. Sir Beauchamp Seymour will be instructed to co-operate with you and render you every assistance in his power. Her Majesty's Government consider that the protection of the Suez Canal should be undertaken by the Fleet; you will communicate with the Admiral on this point and ascertain his arrangements. Her Majesty's Consul-General in Egypt should be the medium of any communications which you may deem necessary to make to His Highness the Khedive."

THE NEW PEERS.

Vice-Admiral Sir Frederick Beauchamp Paget Seymour, G. C. B., Commander-in-chief of the Mediterranean Fleet, is the second but only surviving son of the late Sir Horace Beauchamp Seymour, M. P., by his first wife, Elizabeth Mallet, daughter of Sir Lawrence Palk, Bart., and grandson of Vice-Admiral Lord Hugh Seymour. He was born in London on April 12, 1821, was educated at Eton, and entered the Royal Navy in January, 1834, receiving his lieutenant's commission in March, 1842. He served as a volunteer in the Burmese war of 1852–3 as aide-de-camp to General Godwin, and led the storming party of Fusiliers at the capture of the works and pagoda of Pegu. He was also present in numerous other engagements on land and water, was four times gazetted, and awarded the Burmese medal with the clasp for Pegu, at the close of the campaign. In 1854 he served against the Russians in the operations in the White Sea, and is in receipt of the Baltic medal. A few years later, viz. 1860–1, as commodore in command of the Australian station, he took part in the operations of the Naval Brigade in New Zealand, again distinguishing himself, and receiving the New Zealand medal and the Companionship of the Bath. From 1868 till 1870 he was private secretary to the First Lord of the Admiralty, and he commanded the detached squadron from December, 1870, till May, 1872, from which date till March, 1874, he was one of the Lords of the Admiralty. From October, 1874, till November, 1877, when he was made a

K. C. B., he commanded the Channel squadron, and was appointed Commander-in-Chief in the Mediterranean in February, 1880. Later in that year he was senior naval officer of the European demonstrative squadron, and received the thanks of the government for the manner in which he performed that duty, being created a Grand Cross of the Bath in the following year. Sir Beauchamp has been aide-de-camp to the Queen from October, 1866, and a Fellow of the Royal Geographical Society, and a corresponding member of the Royal United Service Institution.

Lieutenant-General Sir Garnet Joseph Wolseley, G. C. B., G. C. M. G., LL. D., D. C. L., is descended from a family originally belonging to the county of Stafford, where they had been settled from before the Conquest. The family was noble at the time of the Plantagenets, and among the first creations of baronetcies by James I. is found the name of Wolseley. A grandson of the second baronet also received the cognisance of the "red hand" in 1744, and the younger son of this gentleman, who served in the 8th Hussars, was father of the late Major G. J. Wolseley, of the 25th regiment, the father of Sir Garnet Wolseley, by his union with Frances Anna, daughter of Mr. William Smith, of Golden Bridge House, near Dublin. Sir Garnet was born at Golden Bridge House, county Dublin, on June 4, 1833, and educated at a private school and under tutors. He entered the army as an ensign in the 12th Foot in March, 1852, but on the 13th of the following month was transferred to the 80th regiment. His first service was in the Burmese war of 1852–3, for which he received the medal for Pegu, and he was with the expedition under Sir John Cheape against the robber chief Myattoon, being severely wounded in the attack on that chief's stronghold. Landing in the Crimea with the 90th Light Infantry in December, 1854, he was employed in the trenches as acting engineer until Sebastopol was taken, being severely wounded in a sortie, and several times mentioned in despatches. For his services he received the medal with clasp, was made a knight of the Legion of Honor, received the fifth clasp of the Medjidie and the Turkish medal. He next served in the Indian campaigns of 1857–9, was repeatedly mentioned in despatches, and received the brevet of lieutenant-colonel, and the medal with clasp. In the war of 1860, in China, he served upon the quartermaster-general's staff, and was present at the assault of the Taku forts, and in all the engagements throughout the campaign, receiving another medal with two clasps. Ten years later he commanded the expedition sent

from Canada to the Red River territory, for the suppression of the rebel government established at Fort Garry against the Queen's authority, and was created a knight of St. Michael and St. George for his services upon that occasion. He was governor and commander of the forces on the Gold Coast during the Ashantee war of 1873–4, and for his services then received the thanks of both Houses of Parliament; was promoted to be major-general for distinguished service; nominated a G. C. M. G. and K. C. B., and received the medal with clasp. In the last named year he was despatched to Natal to administer the government of that colony from November, 1875, till November, 1876; was inspector-general of the auxiliary forces at the headquarters of the army; at the latter date was appointed a member of the council of India, and in 1878 high commissioner and commander-in-chief of the Island of Cyprus. In June, 1879, he was sent to South Africa as governor and high commissioner of Natal and the Transvaal, to reorganize the affairs of Zululand, and on that occasion conducted the operations against Lecocoeni, whose stronghold he destroyed. Returning in May, 1880, he was appointed quartermaster-general at the headquarters of the army, and in April last succeeded Sir Charles Ellice as adjutant-general of the army. Sir Garnet Wolseley, who married in 1867, Louisa, a daughter of Mr. A. Erskine, was appointed General Officer Commander-in-Chief, with temporary rank of General, of the expeditionary force proceeding to Egypt.

NAVAL INSTITUTE, WASHINGTON BRANCH,

DECEMBER 21, 1882.

REAR-ADMIRAL THORNTON A. JENKINS, U. S. N., in the Chair.

CHANNEL IMPROVEMENT, WASHINGTON NAVY YARD.

By Civil Engineer A. G. Menocal, U. S. N.

In complying with a request to prepare a paper for the Naval Institute, I have presumed that I may be permitted to take up and discuss a subject not directly relating to naval matters, but yet one that may profitably occupy the attention of this Institute. I shall have attained the object sought if this presentation leads to the further discussion of a subject which, falling directly within the profession of the civil engineer, at the same time concerns the naval service through its bearings over the question of maintenance and enlargement of the Washington Navy Yard, one of our most valuable naval stations, the efficiency of which would be greatly promoted by a happy solution of the problem suggested by the title of this paper. Therefore, it is not proposed to dwell upon the value of the Yard as a base of operations for offense and defense—that can better be done by other members of the Institute, students of military science—but as the conditions combine to make it an important manufacturing station, so also may they, if properly utilized, contribute to convert it into an equally valuable building establishment. These conditions are too well known to require from me special reference; I may, however, call attention to the fact, that however valuable in the abstract, they are all subservient to the important factor, the accessibility of the Yard to seagoing vessels.

This channel does not, in its present condition, satisfy the requirements of the station, and so the Yard cannot satisfy the requirements of the service. The accompanying chart, prepared from

data obtained by recent carefully conducted surveys, shows that the channel through which once floated the Minnesota, and even ships of twenty-four feet draught, in front of the Yard and for some distance below, now has a mean maximum depth of twenty feet and minimum depth of thirteen feet. Whatever be the causes that have produced these results, it is indisputable that they are still active, and unless some effective means are provided for arresting these causes, and for enlarging and preserving this channel, the few of our vessels of war which can still reach the Yard will be shut out, and no craft larger than a yawl or a flatboat will enter the Eastern Branch.

The numerous shops and valuable plant accumulated at immense cost, and so efficiently employed in the past in producing the best materials for the use of the Navy, and which might and ought to be employed in building the new navy, will become useless and well nigh valueless. At the present time, only by the removal of no less than a million cubic yards of silt, could channel dimensions commensurate with the immediate needs and purposes of the station be obtained. That, however, would afford but temporary relief, for unless some other means are devised for maintenance, this navigable track can only be kept open by continuous dredging at an annual expenditure of a large sum. The difficulty of obtaining a yearly appropriation for that purpose is apparent to all, and attested by the present condition of the channel. It is necessary therefore to look to other means for securing the same results at less expense.

It is not my purpose to present in the following discussion any novel theories of hydraulic engineering, or to enlarge on those already known to the profession; my object is rather to determine certain physical conditions, to measure and weigh the active forces, and then to ascertain if their action cannot be modified by the application of some well-defined fundamental laws, and certain desired effects produced.

The Eastern Branch partakes more of the nature of a long inlet or estuary than of a river. Owing to a limited water-shed, of about 115 square miles, the stream above the tidal compartment has an ordinary flow of only 106 cubic feet per second, and may be denominated a small creek. In the lower portions its volume fluctuates with and is mainly due to the action of the tides. There appears to be a tradition to the effect that in former years a uniformly deep channel extended from the Potomac to Bladensburg, the latter point having been accessible to large schooners. The writer has not been able to obtain any

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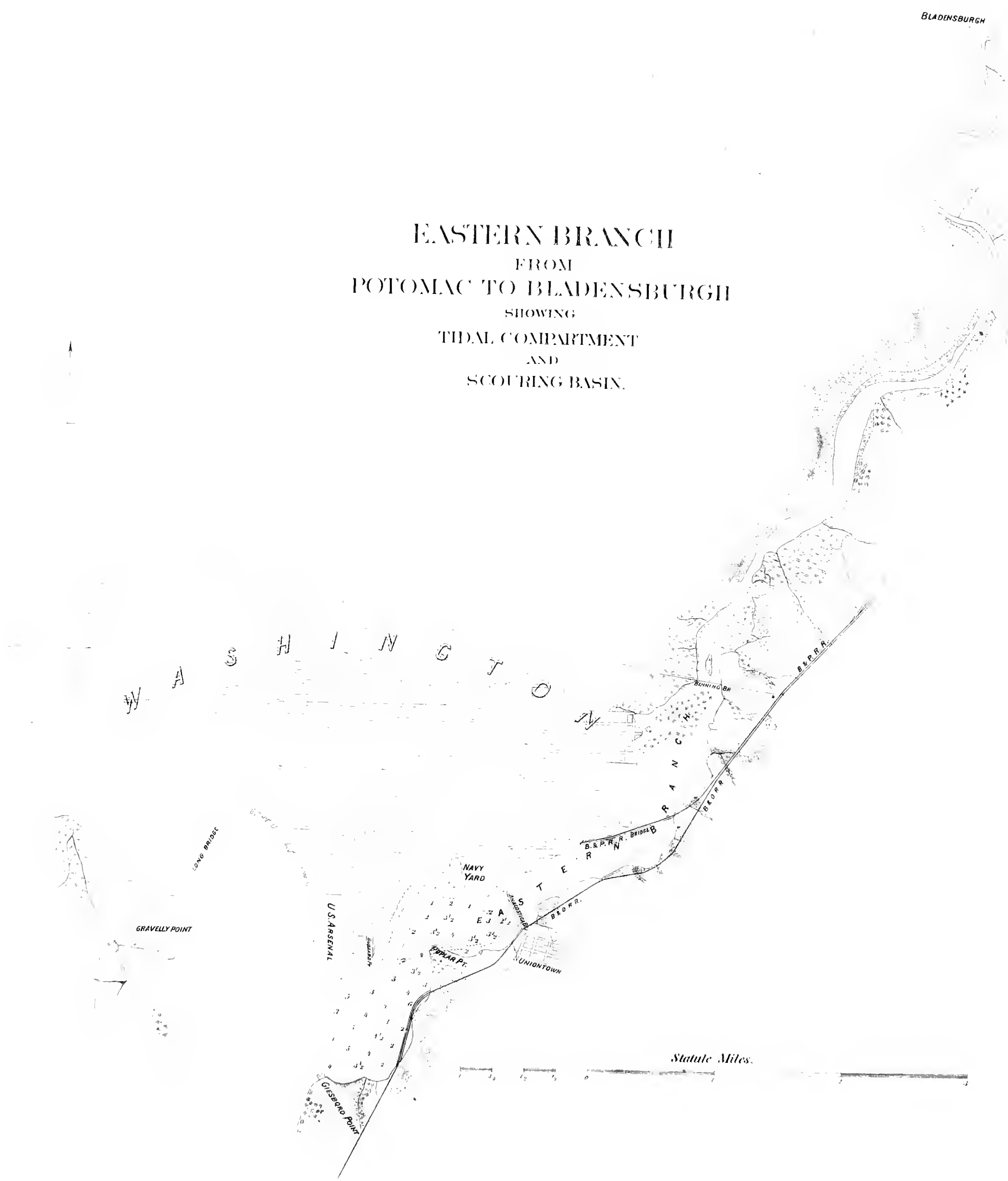
Fig. 2.

EASTERN BRANCH
FROM
POTOMAC TO BLADENSBURGH
SHOWING
TIDAL COMPARTMENT
AND
SCOURING BASIN.



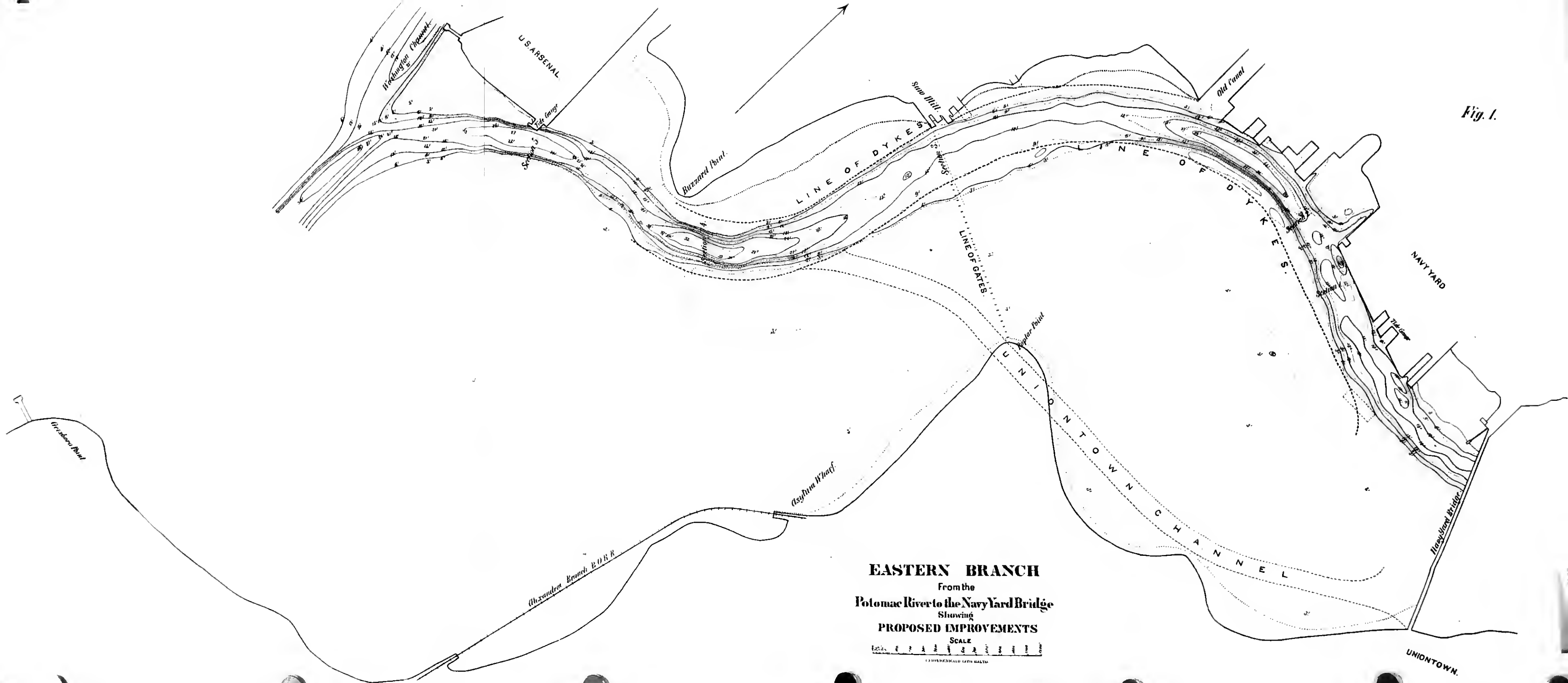


Fig. 1.
U.S. ARSENAL
Washington Channel
Tide Gauge
Buzzard Point
Saw Mill
LINE OF DYKES
LINE OF DYKES
Old Canal
LINE OF GATES
NAVY YARD
Poplar Point
UNIONTOWN CHANNEL
Navy Yard Bridge
UNIONTOWN
Giesboro Point
Asylum Wharf
Alexandria Branch B. O. R. R.
EASTERN BRANCH
From the
Potomac River to the Navy Yard Bridge
Showing
PROPOSED IMPROVEMENTS
SCALE

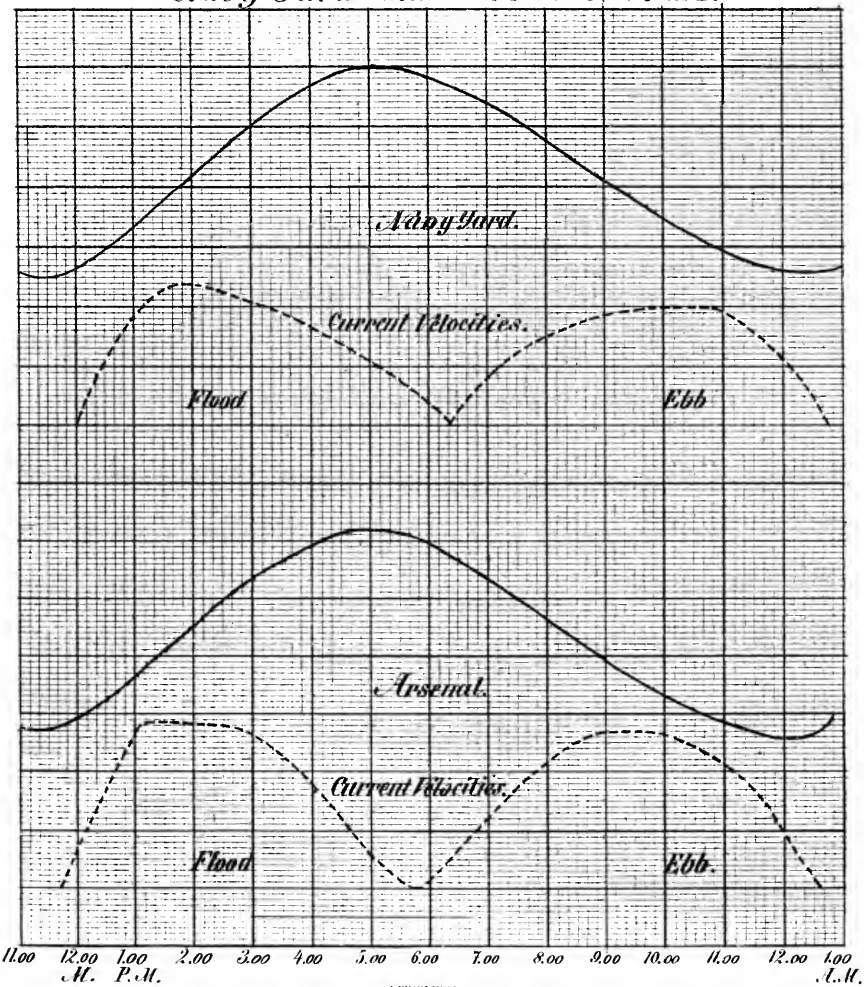
map confirming that statement, but its accuracy is admitted. The present condition of the channel may be explained when we consider the accumulated work of the tides and their tendency to silt up the river to the extent of their influence as I shall endeavor to show further on, and the disintegration and wash by the rain of the adjoining lands which include the whole water-shed of the Potomac river above Washington, formerly covered with forests or thick vegetation, but now nearly bare the greater portion of the year and constantly turned up for agricultural purposes. A comparison of the chart herewith submitted (Fig. 1) with a map of the river from the Potomac to Bladensburg, completed by the United States Coast Survey in 1861, shows a marked reduction in the depth of both the channel and the area of the marshes or flats, and a reference to local surveys, conducted from time to time in the vicinity of the Yard, indicates that the silting of the river progresses as the depth decreases. The object of the following discussion is to show that this deposition of sediment is largely due to the action of the tides, and that unless the existing physical conditions are modified with a view to turn to advantage what is now a serious evil, the river will be hopelessly lost for the purposes of navigation (except, as before stated, through a judicious and expensive system of dredging), and as a consequence, the tidal portion of the stream will be converted at no distant day into a pestilential swamp, a receiving-basin of nauseous sewer deposits, and a nuisance of equal proportions and not inferior in its malarial developments to the one west of the city now in process of eradication at an enormous expenditure of public money. It is proposed to point out the method by which those tendencies may be diverted from their present work of destruction, and the forces now acting to destroy, turned to advantage and usefulness.

Tide-gauge observations at the Navy Yard for a period of over nine months show the mean range of the tide to be 3.1 feet, and the mean duration of the flood tide five hours and thirty-five minutes, while that of the ebb-flow is six hours and forty-nine minutes. It is evident that the water moving out through a given sectional area at each ebb tide is equal in amount to that flowing in with the preceding flood, plus the discharge of the river above the tidal compartment during the ebb and flood. In the present case the latter amount is but 0.006 of the former, consequently the mean velocity of the flood current opposite the Navy Yard must be greater than that of the ebb in the proportion of the duration of the tidal flow, or as 121 is to

100; and as the scouring power of the current increases as the square of the velocity, the amount of sediment transported up stream by the flood must be greater than that carried down by the ebb, a fact which may be accepted as a marked indication that there is a constant deposition of material tending to silt up the stream. Figure 3 is an illustration of and seems to verify the foregoing conclusions. It represents the tidal and current curves of a mean tide, constructed from careful and simultaneous observations at both the Navy Yard and Arsenal Wharf. The time of highest and lowest level of water and the precise moment of the turning of the tides were carefully noted, and the current observations were taken with great precision at intervals of ten minutes during the flood and ebb of the same tide. Similar observations were made for a period of seventy-two hours at the two above-named stations, at the Baltimore and Potomac Railroad Bridge and at Benning's Bridge across the branch; but the results for current velocities at the last two stations were somewhat disconnected and unsatisfactory, for while they seem to possess the same salient features of those taken with greater care at the Yard and Arsenal Stations, the plotted curves do not present the desired regularity in outlines, and they are not presented. The full lines in the figures represent the tide curves, and the broken lines the current velocity for the flood and ebb of the same tide. The rise and fall at the Yard is 3.45 feet, or 0.35 foot in excess of the range determined by more prolonged observations. It took the flood tide 5 hours and 5 minutes to reach that height, while the ebb consumed 6 hours and 40 minutes in descending to a level but $\frac{1}{10}$ of a foot lower. The proportional duration of the flow of both the flood and ebb tides, as obtained from these observations, does not verify the deductions made from the gauge readings. This is explained by the fact that the water continued to move in and out of the estuary for some time after reaching its highest and lowest level as will be shown hereafter. We shall have occasion to show however that the conclusions previously arrived at, as before stated, are verified by the last observations, and by a different process. The flood current at the Navy Yard, as will be seen from the curve represented in Fig. 3, attained a maximum velocity of 2.25 feet per second during the second quarter of the flow, while the ebb current in the same tide did not reach its maximum speed of 2.01 feet per second until the end of the third quarter. The rapid increase in the velocity of the flood current during the first stage of the tide, and the decided retardation of the speed imme-

Tide and Current Velocity Curves of Navy Yard and Arsenal Wharf.

Fig. 3.



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Tide Curves on the

Oct. 12th 1882.

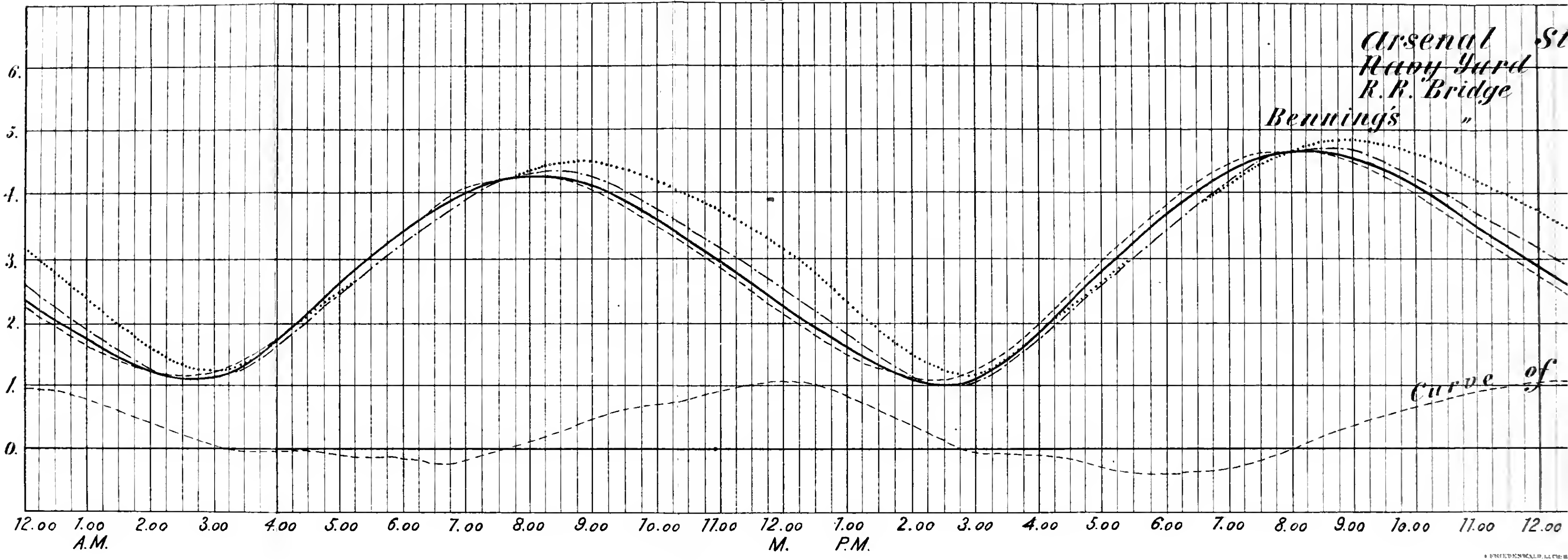
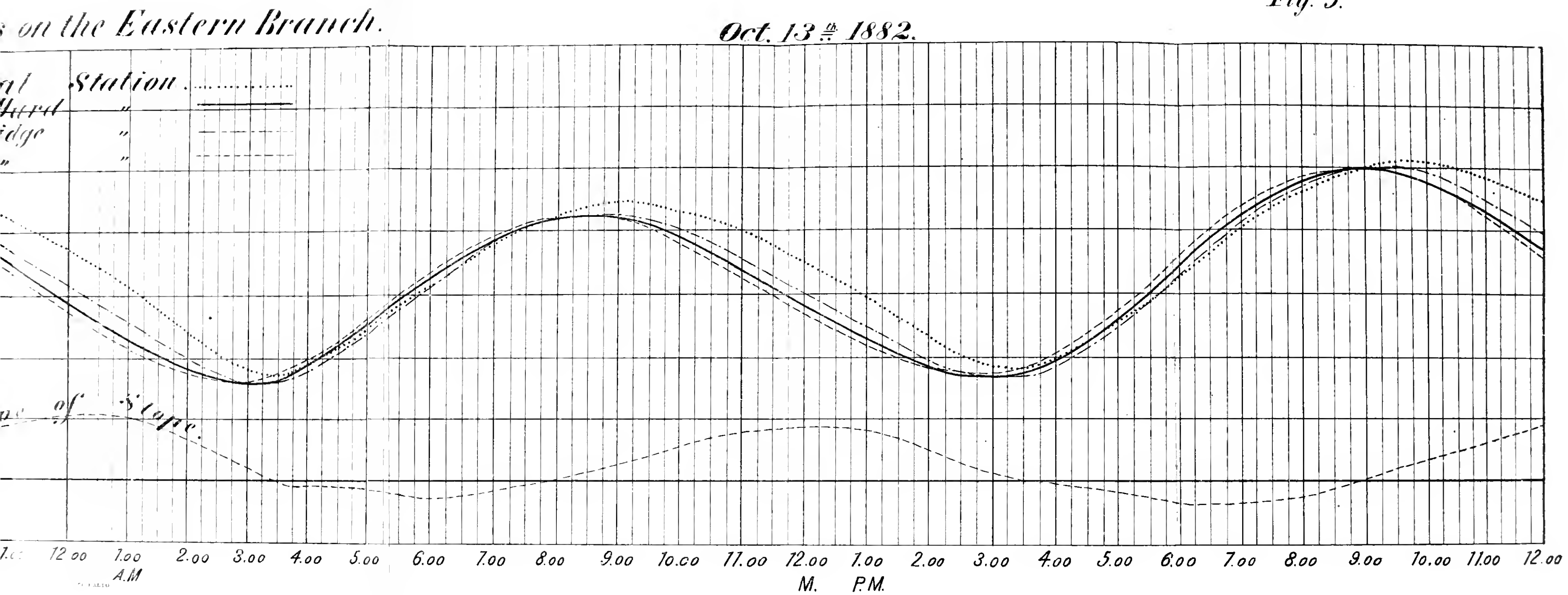


Fig. 5.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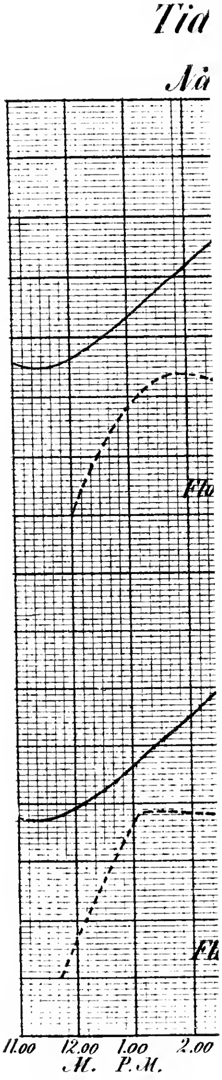

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diately following the maximum velocity, seem to be explained by the fact that the rising tide is heaped up as it were at the mouth of the river by the dynamic force of the flowing stream at the end of the preceding ebb, and when this force is at last overcome and the slope reversed, the impeded flood waters are propagated up stream in the form of a wave of translation, filling first the main deep channel of the river where the frictional resistance is least, and as the tide rises, spreading over the banks and adjoining flats with a velocity retarded by increased friction. The velocity curves show that the flood tide continues to run in at a uniformly decreasing velocity for an hour and a half after the water has reached its highest level, and slack water does not occur until the level at the gauge has fallen three-tenths of a foot both at the Yard and Arsenal. This last effort of the impetus acquired by the flowing liquid is evidently expended in filling up the extensive and distant coves above the Yard, and in piling up the waters at the upper contracted part of the tidal portion of the river, as shown by the gauges at the railroad and Benning's bridges registering a higher level by more than one-tenth of a foot than at the Navy Yard and Arsenal Point (see Fig. 5).

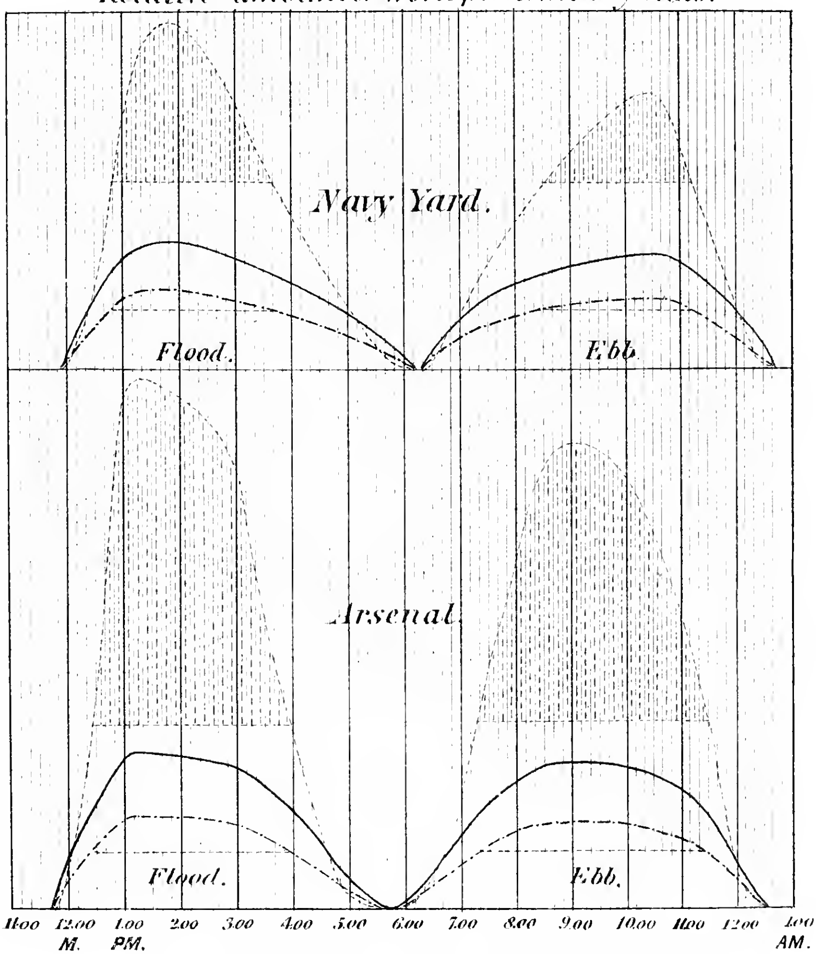
The ebb tides are not distinguished by any of the peculiarities pointed out in the foregoing remarks as pertaining to the flood, except, as shown by the curves, that the water continues to run ebb after reaching the lowest level, and until its surface has risen one-tenth of a foot on the gauge. This is due—as remarked before—to the dynamic force of the outflowing waters while expending their last effort in opposing the flood-wave approaching from an opposite direction. The tide curves at the four stations (Fig. 5) show a well-defined surface slope during the whole duration of the ebb flow, and the current curves are a clear illustration that the velocity increases with the slope of the surface, the maximum speed coinciding with the maximum fall. During the flood, the slope and the velocity (Figs. 3 and 5) are at variance. The maximum velocity of the flood current at the Navy Yard (Fig. 3) is 2.25 feet per second, and that of the ebb current 2.01 feet per second, the latter being 0.89 of the former. This might be accepted as an indication pointing to the accuracy of the foregoing statement, that the sedimentary matter brought up by the flood tide is greater in amount than that carried down by the ebb. But the flood current attains its maximum speed as if by an impulse, at a time when the rising tide has ascended but 0.44 of its total range, and this high velocity is retained only for a comparatively short time,

after which the momentum acquired by the moving waters seems to be sufficient to overcome the resistance of gravity in raising the whole mass to the remaining 0.56 of the height and the velocity gradually falls to nothing. The ebb current, on the other hand, increases less rapidly. It takes 52 minutes to reach the velocity acquired by the flood in the first 34 minutes of its flow, but the steady increase of velocity seems to be more uniform and consistent with the head to which it is due. The maximum speed is not acquired until the waters have fallen 0.76 of the total height, and when attained, it is preserved for a longer time than in the flood, so that the momentum acquired by the receding waters is expended during the interval of two hours, in reducing the level 0.15 of the height, and in an effort toward overcoming the initial velocity of the returning tide. It remains to be seen, therefore, whether the fact of a higher speed in the flood than in the ebb can be accepted as conclusive evidence that the scour, or accumulated work performed by the former is larger than that accomplished by the latter. With this object in view, the bottom velocities, as obtained by calculation from the surface velocities, have been plotted in the diagram for both the Navy Yard and Arsenal Stations. It has been assumed that a bottom velocity of one foot per second is required to lift and carry forward light sand and clay recently deposited, and that all bottom velocities equal to and greater than the adopted unit will be capable of performing a certain amount of scour of the material taken as a basis or in heavier deposits, while all velocities below that unit will have no effect, or the current will exert its influence only on lighter sediment held in suspension. Acting on these premises, the correctness of which will not however affect the ultimate results, since the latter are not intended to have an intrinsic value, but are presented only as an illustration of the relative effects produced by the same forces acting under similar conditions, and since we know that the scour increases with the square of the velocities, the curves of *work* for both the flood and ebb tides at the two stations have been constructed, the vertical scale having been very much distorted to avoid confusion of lines (see Fig. 4). At the Navy Yard, the areas contained within the ebb and flood curves above the one-foot velocity are in the ratio of 160 to 307, or in other words, the *work* performed by the former is only 0.52 of that performed by the latter. At the Arsenal Point, the same areas stand in the ratio of 851 to 936, or the scour of the ebb tide is but 0.91 of that of the flood.

The difference in the ratio of the accumulated *work* done at the

Fig. 4.

Velocity Curves and Areas.
showing
Relative amount of work performed by tides.



Indicates Square of Bottom Velocity.
" Surface Velocity.
" Bottom "

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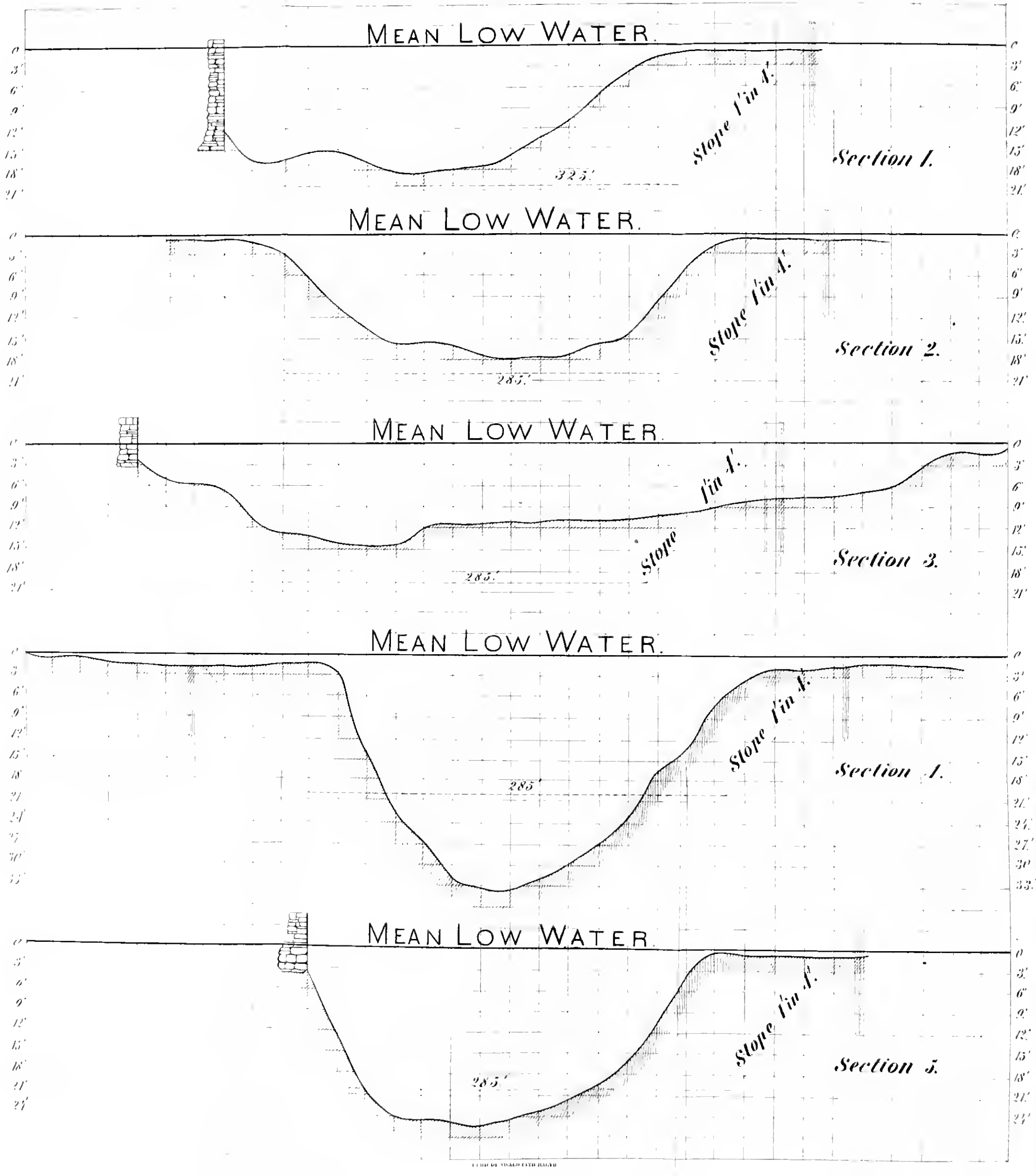
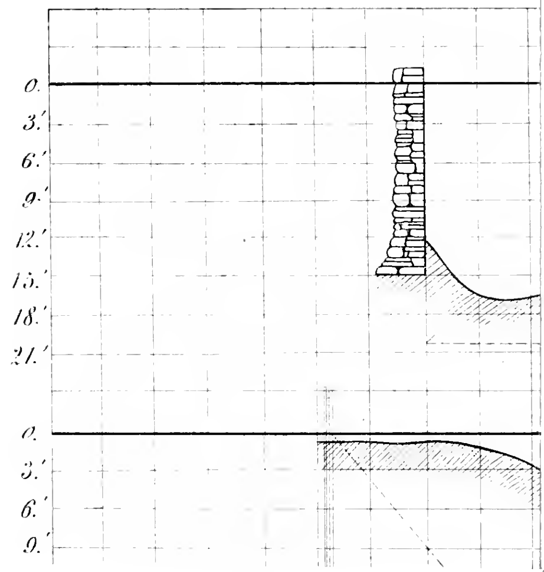
Cross Sections of Present and Proposed Channel.

Plate 6.

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two stations is explained by the fact that the volume of water flowing in and out at the Yard Station is but 76 per cent. of that passing through the sectional area of the estuary at the Arsenal, and as a consequence thereof, the area of the main channel at the latter is, as might well be expected, found to be 12 per cent. greater than that at the Navy Yard (see Figs. 1 and 5, Plate 6). It is quite interesting to observe how closely these results verify each other, and that the correctness of the conclusions advanced at the outset, as suggested by the relation between the duration of the flood and ebb, is also confirmed by the ratio of the accumulated *work*, or capacity for work, of each tide. The term *work*, as used here for convenience, is not intended, as before remarked, to represent the cubical contents of sedimentary matter carried up or down the stream by the tides, or the material deposited in the channel through a lack of transporting power in the flowing waters. The curves are only given as an illustration of the relative capacity of the currents to accomplish work under certain conditions; beyond that they have no meaning. The shaded areas represent the product of two of the variable factors entering into the calculation, viz. velocity and time; the other factor, resistance, is constant, and can be eliminated without destroying the relation sought.

The amount of material referred to as being transported or deposited is dependent on the quantity of sedimentary matters held in mechanical suspension by the waters, which in the present case are obtained from two distinct but similar sources, and are due to two causes. The sources are the Potomac river and the Eastern Branch, the waters of which are being constantly intermixed as they are moved up and down the streams by the tidal oscillations. The causes are, first, the force of the current in those streams due to both the tides and land floods and its power to hold in suspension and transport earthy matter, and second, the drainage of the two water-sheds. The quantity of material proceeding from the latter cause is a function of both the amount of rainfall in a given time and the condition of the surface drained, and may be estimated by the turbid character of the surface of the water after every continued or violent rain. Through the influence of these several causes the condition of the water as to turbidity is constantly changing. Thus the streams may one day be charged with sediment to their maximum capacity, and on the next the waters may be comparatively free from earthy matter, or the waters of the river

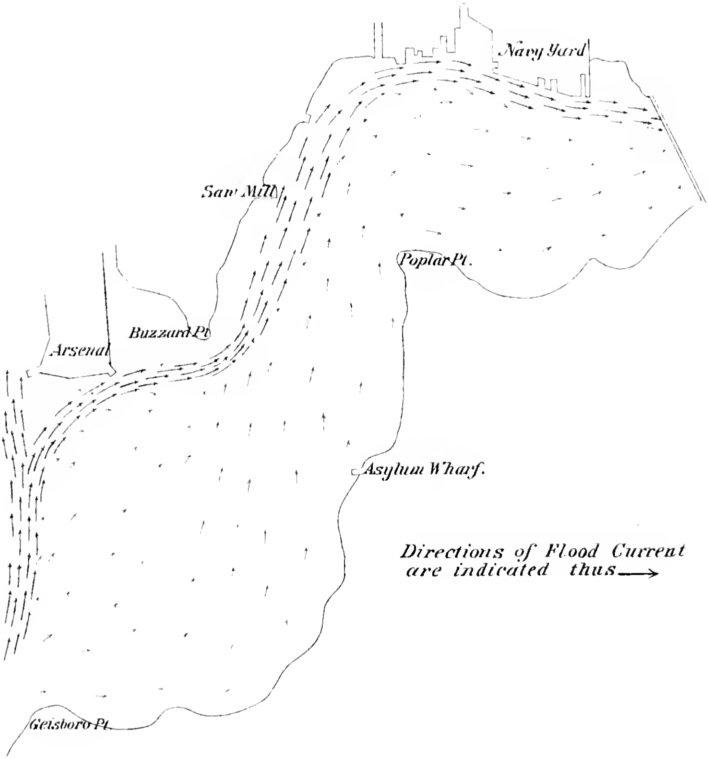
may be very turbid, while those of the "Branch" are much less so, but upon being mixed by the tides, new and variable conditions result. Any attempt therefore, having for its object the determination of the quantity of sediment contained in the river at this locality, would be involved in much labor and uncertainty, and no practical or useful result could be reached.

The foregoing discussion seems to conclusively establish, that unless the present regimen and conditions of the river are modified, the process of silting will continue, and water communication with the Yard will be greatly impaired, or practically cut off within a limited period.

The method here proposed for the improvement of the channel—for its permanent enlargement—is based on a concentration of the flood-waters in a scouring basin, embracing a superficial area of 73,502,765 square feet, or 66 per cent. of the total tidal portion of the estuary, and then to discharge the stored waters at a high velocity during the ebb tide, through a channel where they may flow with the least frictional resistance, and possess a scouring energy much greater than that of the flood-tide moving through the whole estuary, a velocity sufficient, it is believed, to scour and carry forward the sedimentary matter composing the bed of the river, so forming a deep and wide channel, and an established equilibrium between the current and the material. It is proposed that the navigable channel shall be confined on its southern margin by a longitudinal dike or bulkhead of sheet piling, extending from a point above the Navy Yard to the end of the bend at Buzzard Point, and on the north side by the yard wharves and by short sections of dikes connecting projecting points in the banks. (See Plate 1.)

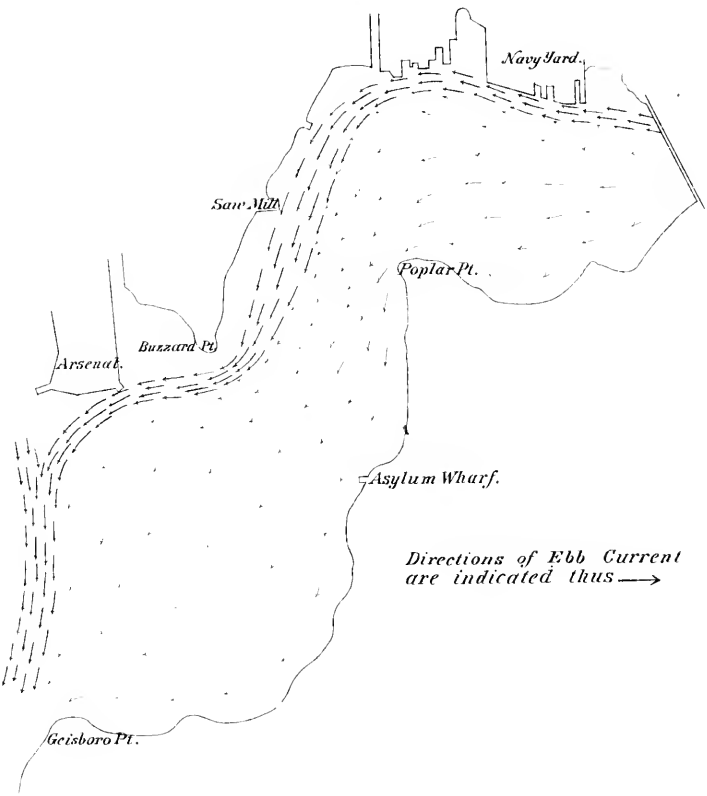
It is to be regretted that the present tortuous channel cannot be rectified by cutting off its sharp bends and establishing instead a more direct passage from the Yard to the Potomac. Such a radical change cannot however be made, without serious interference with the riparian rights of lands abutting, nor without interfering very materially with the propagation of the flood tide. The bends, however, have been made less abrupt than they now are, the general direction improved, so far as the controlling circumstances will permit, and although the channel embraced by the training dikes may not be, apparently, of as easy access to navigation as a more direct one, yet the fact cannot be overlooked that in a straight channel the water has a tendency to deviate or oscillate from side to side, and thus produce shoals and bends in the *thalweg* injurious to navigation, while in a

Fig. 7.



A. FRIEDENWALD, LITH. BALTO.

Fig. 8.



FRIEDENWALD LITH BALTO

curved channel the centrifugal force keeps the current constantly against the concave bank, where the greatest uniform depth is always found.

It has been thought advisable to extend the training dikes to the bend opposite Buzzard Point, in order that the confined waters may continue to exert their scouring power and preserve the required depth to that point. It will be observed from the chart, that the deepest water between the Yard and the Arsenal is found opposite that point. Both the enlarged sectional area and the bend in the channel are due to the concentration at that point of the ebb and flood tidal currents approaching from different directions, as represented by the arrows in Figs. 7 and 8. On the turning of the tide to flood, the water follows the line of least resistance, flowing through the main channel at a high velocity and spreading over the flats with a current retarded by friction. But as the level rises, the waters covering the extensive flats extending from Giesboro Point to the Asylum wharf, flow in lines concentric with the bank toward the lower level up the Branch, and impinging against the main channel opposite the Point, press, as it were, the fluid mass against the bank, causing a diversion of the main channel toward the right bank of the river. During the ebb a like effect is produced by similar causes acting in the opposite direction. The receding waters from the flats of the Branch, being deflected by Poplar Point, are thrown against the stream moving down the main channel, and the accumulated waters thus compressed are forced in the direction of the resultant of the combined forces, which lies in the channel previously occupied by the flood waters. This explains, and is also confirmed by the anomaly observed in the sectional area of the channel opposite Buzzard Point (see Fig. 4, Plate 6), that shows deepest water toward the convex side of the bend and the action of the centrifugal force on the concave side limited to the six foot curve. It explains also the persistent formation of the bar opposite the saw-mill. The alternate action of the tides, the flood wearing the left bank and the ebb the right bank of the channel, combine to form an enlargement of the sectional area, where the scouring action of the current is limited to the depth of 13 feet. The proposed plan will alter the present conditions, inasmuch as all the ebb waters will be concentrated in the main channel, and therefore the necessity of continuing the regulating dikes to the end of that curve.

The flushing or scouring basin will be bounded by the dike on

the south side of the channel to a point opposite the sawmill wharf, and from this point by a line of gates to Poplar Point. At the upper end of the dike above the Yard, the channel will be in communication with the basin so as to permit the flow of the waters in the main channel at all times. It will be observed, however, that the proposed plan does not involve the discharge of the stored waters at or near the level of low water, with the high velocity due to the increased head. That system would require a construction more costly and complicated in design than is now contemplated, and the final result might not justify the expenditure involved. The system of scouring by directing a stream of water with a high velocity directly upon a particular spot, may be found effective in removing deposits from a determined place, to be again deposited at a distance below. In the present case a moderate amount of water confined in a well proportioned channel, will be found quite ample to produce a current sufficient in bottom energy to effect the object in view. A velocity of one foot per second will suffice to remove the light material composing the bed of the stream, but the current should be as uniform as possible, otherwise its effect might prove injurious instead of beneficial, since local commotion can only be produced at the expense of power, and the heavy material removed by an impulse of the current at a given point will be deposited at some other where the velocity is less.

It is the object therefore to leave the basin permanently open to the channel, both for the influent and effluent waters, or in other words, the channel will be an integral part of, and may be regarded as an extension of the basin. By the flood tide, the whole basin of the Eastern Branch above Poplar Point will be filled as now, the waters moving to fill this reservoir through a sectional area of 11,066 square feet at mean tide, while the flow of the ebb over the flats will be stopped by the gates, and the outlet will be restricted to the new Navy Yard channel enclosed by training dikes, and having a mean sectional area of 7308 square feet.

The basin will have a total superficial area of 73,502,765 square feet. Of this amount 67,671,565 square feet are comprised in that portion of the tidal compartment of the river where the mean range of the tide is practically the same as that determined by the observations at the Navy Yard, viz. 3.1 feet; the remaining 5,831,200 square feet of the superficial area embrace that portion of the river where the gradual rise of the bed above the plane of low water reduces the rise and fall of the tide to an average

of one-half the mean, or 1.55 feet. We have therefore the cubical contents of the tidal prism contained in the basin at mean high water 218,820,211 cubic feet. To this amount must be added the ordinary drainage of the water-shed of the Eastern Branch during the ebb. This discharge is 3650 cubic feet per minute, which into the time, 6 hours and 21 minutes (the duration of the ebb as shown by the current observations) gives a total discharge of 1,390,650 cubic feet. Adding the cubical contents of the tidal prism, 218,820,211, we have total discharge of basin during ebb flow=220,210,861 cubic feet, which divided by the time, 6 hours and 21 minutes, the duration of the tide, will give 9633 cubic feet as the mean discharge per second on the basis of a steady flow. It is proposed to impart to the ebb tide a maximum velocity of 2.50 feet per second, and this divided by a coefficient, will give the mean surface velocity from which the mean velocity of discharge and the proportional sectional area can be obtained.

Rankine gives this coefficient 1.57 for both the ebb and the flood current. Our current observations at the Yard and Arsenal wharf give the following results:

Velocities at the Yard.

Flood, ... Maximum, 2.250. Mean, 1.392

Maximum divided by Mean, $\frac{2.250}{1.392} = 1.617$

Ebb, ... Maximum, 2.010. Mean, 1.324

Maximum divided by Mean, $\frac{2.010}{1.324} = 1.518$

and $\frac{1.617 + 1.518}{2} = 1.568$ the mean coefficient.

Velocities at the Arsenal.

Flood, ... Maximum, 2.800. Mean, 1.758

Maximum divided by Mean, $\frac{2.800}{1.758} = 1.596$

Ebb, ... Maximum 2.630. Mean, 1.691

Maximum divided by Mean, $\frac{2.630}{1.691} = 1.556$

and $\frac{1.596 + 1.556}{2} = 1.576$ the mean coefficient.

Rankine's coefficient of 1.57 as a mean for both the ebb and flood current is, therefore, verified by these observations, which it may be proper to add were simultaneously taken at intervals of ten minutes, and with all the requisite care to ensure accurate results. For our calculations we will use the constant obtained from the ebb current observations at the Navy Yard.

$$\frac{\text{assumed maximum surface velocity} = 2.50}{\text{constant for ebb current} = 1.518} = 1.647 \text{ mean surface}$$

velocity, instead of 1.392 for the flood and 1.324 for the ebb as obtained from our observations.

From this mean surface velocity we can obtain the mean velocity of the flow and the velocity of the bottom by the following formula:

$$V' = (\sqrt{v} - 1)^2 \qquad = \text{mean bottom velocity.}$$

$$V'' = \frac{(\sqrt{v} - 1)^2 + v}{2} = \text{mean velocity of the flow, in which } v =$$

mean surface velocity in inches per second; hence $(\sqrt{19.764} - 1)^2 =$ 11.868 inches $=$ 0.989 feet per second, the bottom velocity, and

$$V'' = \frac{0.989 + 1.647}{2} = 1.318 \text{ mean velocity.}$$

The mean discharge per second divided by mean velocity will give the required area of channel to carry off the stored waters at a maximum surface current of 2.50 feet per second, hence $\frac{9633}{1.318} =$ 7308 square feet $=$ the sectional area. With this sectional area there will be at each ebb tide an interval of 3 hours and 50 minutes in which the bottom velocity will be between 0.989 and 1.687 feet per second, with a sufficient scouring power to lift and carry forward material as heavy as coarse gravel. It is reasonable to expect that, with such a current, acting for nearly eight out of the twenty-four hours of each day in a well-proportioned channel where the waters are confined and guided so as to exert their whole influence on the bottom and sides of the stream, no danger of additional deposits from any source need be apprehended. The bed of the river is composed of sand and clay, and this light material once lifted by the current will not be deposited again in any portion of the channel. A portion of it may be deposited on the flats and eddies in the wide parts of the main river, and other portions may not find rest until they have reached the sea.

As to the land floods their effect will be to rather increase than impair the efficiency of the channel. The enlarged volume will cause

a proportional increase in the scouring, and the material brought down by the flood waters will be moved forward without injury to the channel.

It may be seen from the tidal curves represented in Fig. 5, that the total surface slope between the Navy Yard and Arsenal during the ebb is not at any time greater than one-tenth of a foot. Making the necessary allowance for the increase of head due to a greater velocity, the level of the water confined in the basin will not at any point stand more than two-tenths of a foot above that outside. The design for the dikes and gates, therefore, must be more with a view to an expeditious working of the latter, and to the economical construction and durability of both, than to the pressure they may be called upon to withstand.

The proposed dikes will consist of one row of round piles twelve inches in diameter, varying in length from fifteen to twenty feet, driven eight feet between centres, and connected by two 6″ × 6″ string pieces, to which one row of 3″ planks closely driven to an average depth of fourteen feet will be firmly spiked. The top of the planking, or sheet piles, will project to the plane of mean high water from the head of the channel above the Yard, to the line of gates or lower end of basin, and six inches below that level from the latter point to the end of the dikes at Buzzard Point.

In constructing the dikes through the wide shallow channel opposite the saw-mill wharf, a second row of piles twenty feet long and eight feet between centres will be driven in the rear of and ten feet distant from the first row, to which they will be connected by 6″ × 8″ cross-bracing, so as to resist the additional pressure that may arise from sedimentary deposits behind the sheet piling. This construction is inexpensive both in its original cost and future preservation, and will be found to answer the purpose intended.

Great care and judgment must be exercised in the location and design of the gates, in order that the propagation of the flood-tide and the flood outlet of the river may be retained. The openings of the gates, therefore, should be as large and free as may be consistent with sound principles of construction, and the intermediate piers of no greater dimensions than the stability and management of the gates may require.

Several systems suggest themselves as applicable, but whichever method may in the end be adopted, whether the gates be worked by hand or made to act automatically by a judicious utilization of the

periodic rise and fall in the level of the water, provision must be made to manipulate them as the circumstances may require in times of flood, so as not to obstruct the outflow of the water on such occasions. The level of the water being practically the same on both sides, the purpose of the gates is only to arrest the flow, and divert the ebb, now in part dispersed over the flats, into the main navigable channel. Their desiderata may be stated as follows :—lightness, ease of manipulation, minimum surface exposed to the action of the wind, with a reduction to the minimum of the tendency of ice to impede their free motion and affect their service. The requirements as to manipulation are, that they shall close at high water and so remain until the beginning of the next flood, when they must open and so remain during the entire flood, closing again at the beginning of the ebb. In other words, they are to arrest the flow of the ebb entirely, while on the other hand they are to offer the least resistance to the flood tide.

There is a vast field open to discussion as to the best method of meeting all the necessary conditions, and although the one here proposed is open to improvement in its minor details, and may not, after further investigation of the subject, prove to be the most advantageous, yet it is believed to possess sufficient merit to entitle it to consideration as one of the many solutions of the problem.

The description of the gates may be conveniently and naturally divided into two parts, viz. the substructure supporting and enclosing the gates, and the gates themselves with attached mechanism for working. The former it is proposed to construct as follows: The gate openings, 20½ feet in the clear, will be separated by piers, every alternate one being 2½ feet wide, and consisting of four piles supporting the tanks containing the device for operating the gates. The intermediate pier will be merely a single pile 8 inches in diameter. A sill for the gates to rest on when closed will connect the piers at the bottom, a row of short three-inch sheet piles being driven against the sill to prevent scouring underneath.

It is intended to operate the gates in pairs, and the proposed method of construction and operation is thus described: The gates to consist of slats of galvanized iron ¼-inch thick and about one foot wide, suspended by pivots from the piers at both ends—as are the movable slats of a window-blind—operated by eight connecting rods, four on each side, fastened to a hollow shaft revolving in bearings resting on the piers and tanks. (See Fig. 9.)

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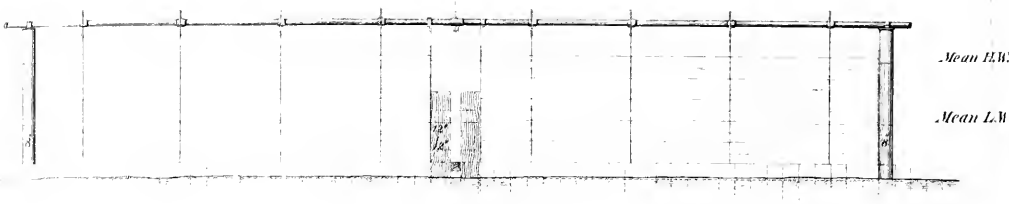


ELEVATION OF ONE PAIR OF GATES. *Fig. 9.*

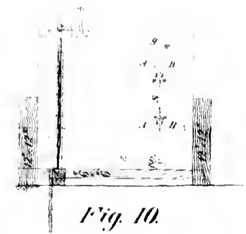
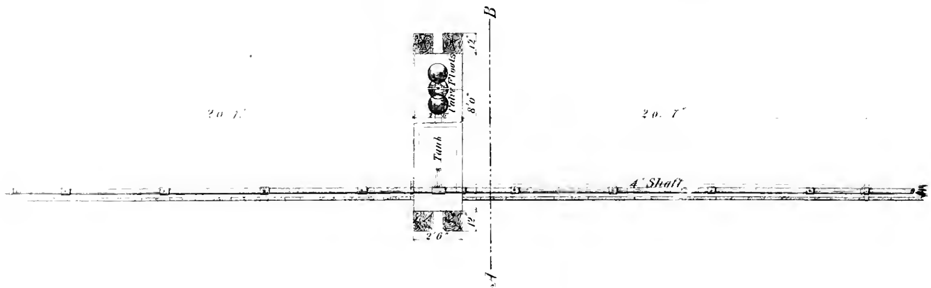


Fig. 10.

SECTION AB
Showing Automatic Valve and position of floats



TOP VIEW OF GATES.

PROPOSED
AUTOMATIC GATES
FOR
IMPROVEMENT OF CHANNEL
NAVY YARD
WASHINGTON

Scale 3/16" = 1'.

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Between the piles of the large piers, and firmly bolted to them, will be placed a galvanized iron tank containing the floats and valves by which the gates will be operated, and the sides of the tanks properly stiffened will support the shaft. Attached to the shaft will be a rigid arm, which, connected to the float in the tank by a suitable link, is raised or lowered by the alternate motion of the float as the water rises or falls, turning the shaft one quarter of a revolution and thereby closing or opening the slats composing the gates.

The interior of the tank will be divided into two compartments, the larger of which will contain the float and have communication with the water outside only as regulated by the valve. The smaller will contain the automatic valve by which the admission and escape of water to and from the float compartment will be controlled, and will have free communication with the water outside.

The valve is connected to a pipe leading from the bottom of the float compartment, and will discharge or admit the water in the tank as controlled by the automatic arrangement. The valve has an arm connected to a small vertical iron rod rising to the top of the tank where it passes through a sleeve, and having two stops so placed that when either is brought in contact with the guide-sleeve the valve will be closed, and when the gate is midway between the stops it will be wide open. On this rod, or valve-stem, works a combination of three floats (see Fig. 10); two spherical wing floats and one small or traveller float playing freely on the valve-stem. The large floats of the combination are attached to arms of a short lever, the inner ends of which are sharpened to enable them better to grasp the valve-stem—as does the paul its ratchet. The fulcrums of these levers play in slotted bearings at the sides of the traveller float, and are held against the inner end of the slot by rubber springs, as shown in the sketch. Each float will be so constructed that the weight will equal its buoyant power when entirely submerged, and the three, if removed from the valve-stem, will float with their centres of gravity in the plane of the surface of the water, and the short levers also lying horizontal in the same plane.

The principal difficulty, met with in all devices suggested for utilizing the rise and fall of the tide as a motor for the automatic operation of the gates, has been to hold back, as it were, the gradual effect of this rise or fall acting through five or six hours, and compel it to exert its influence at the instant of the first impulse of the ebb or flood. This difficulty, it is hoped, has been overcome by the device

described above, suggested by Civil Engineer R. E. Peary, U. S. Navy. The action is made clear by an examination of the sketch, Fig. 10. Starting at low water, the valve open and the valve-floats in the position shown at *A* and *B*, the water outside and in both compartments of the tank at the same level, the large float down and the gate-slats open:—the tide begins to rise, and as it does so the floats cause the sharp ends of the lever *l* to clamp or fasten themselves upon the valve-stem *s*, raising it as they rise, thereby closing the valve *v*, and bringing the lower stop *a* against the guide-sleeve *g*, at the top. As the tide continues to rise, the floats, unable to ascend at first, become more and more submerged, until their buoyant power becomes stronger than the tension of the spring against which they react, when the pivots *p*, *p*, slide outwards in the bearings, the floats rise to and pass the horizontal, the springs force the pivots back to the inner end of the bearings, and the floats assume the position shown by the dotted lines, and rise with the water without further resistance. When the tide reaches its full height the difference of level between the water outside and inside the float compartment is equal, of course, to the range of that tide. The moment the tide begins to fall, the chisel points clamp the valve-stem, and the weight of the floats being thus transferred to it, opens the valve and allows the water to rush into the float compartment, raise the float and close the gates. The valve-stem still descending, closes the valve and brings the upper stop against the guide. Unable to descend further, the floats remain stationary until their weight overcomes the springs and they descend, the pivots, spreading, take the former position and slide easily down the stem with the tide, till it begins to rise again, when they open the valve, the large float descends and the gates are open. In times of freshet the floats will retain their highest position, keeping the gates open and allowing the water to flow through and over all without resistance. On the subsidence of the waters, the regular operations as described above will be resumed.

The total obstruction to the propagation of the flood-tide by the gates and piers is but one-seventh of the sectional area of the flats, which is more than compensated by the increase of area in the main channel, so that there is no reason to expect a higher velocity in the flood current.

Estimates.

The cost of this improvement may be stated as follows:

DIKES.

325	Main piles, 12″ diam. 20′ long, @ 8c. per foot,	$ 520 00
1,250	" " 15′ " " "	1,500 00
325	Bracing piles, " 20′ " " "	520 00
28,000	Lineal ft. white oak, 6″ × 6″ for stringers = 84,000 ft. @ $16,	1,344 00
2,600	Planks, white oak, 3″ × 12″ × 18′ for sheet piling = 140,400 ft.	
10,000	" " 3″ × 12″ × 10′ " = 300,000 ft.	
	440,400 ft. @ $16,	7,046 40
325	Braces, white oak, 6″ × 8″ × 12′ = 15,600 ft. @ $16,	249 60
56,000	Lbs. ⅝ and ¾ inch spikes, @ 4c.	2,240 00
	Total for materials,	$13,420 00

LABOR.

Driving 1900 piles, @ 15c. per foot,	$ 4,762 50
Driving and spiking planking, @ 8c. per foot,	11,744 50
Spiking stringers,	1,050 00
Spiking 325 braces,	243 75
Cutting spikes,	834 00
Handling material and tools,	2,000 00
Total for Labor,	$20,634 75
" Materials,	13,420 00
Total,	$34,054 75
Add 10 per cent.,	3,405 25
Total for Dikes,	$37,460 00

GATES.

120	Piles 12″ diam. 20′ long, @ 10c.	$ 240 00
1400	Lineal feet white oak, 6″ × 6″, for sills, @ $16,	67 20
12,000	Feet B. M. " 2″ × 12″, for sheet piling, @ $18,	216 00
12,000	" " for various purposes, @ $18,	216 00
150,000	Lbs. galvanized iron for gates, tanks, &c., @ 10c.	15,000 00
	Erection,	6,000 00
		$21,739 20
	Add 10 per cent.	2,173 80
	Total for Gates,	$23,913 00
	Total for Dikes,	37,460 00
	Grand Total,	$61,373 00

This amount is regarded as sufficient for the proper construction of the dikes and gates as described above, but provision must be made for a certain amount of dredging which will eventually be required to remove indurated lumps likely to be met with, and to assist the scouring in giving the new channel a sectional area sufficient to navigation and the purposes of the Yard. Figs. 1 to 5, Plate 6, represent the actual cross-section of the river at the four stations marked 1, 2, 3, 4 and 5, and the dotted lines the proposed sectional area enlarged by the scouring power of the current after the improvements are completed; but it is to be expected that unless all obstructions to the uniform flow of the water are promptly removed, the deflected current will be the cause of contraction and eddies, with a consequent loss of power and want of uniformity in the width and depth of the channel. The amount of dredging required for that purpose cannot be estimated now with any degree of accuracy, but the additional sum of $40,000 will, it is believed, be ample to cover all contingencies under that heading. To accomplish the object proposed by the improvements by dredging alone, no less than $250,000 would be needed at the outset, and for maintenance of the channel an additional annual expenditure which cannot be estimated at less than $20,000, or a much larger amount in proportion if the silt is allowed to accumulate for a considerable length of time.

As to the permanency of the works proposed, it may be said that for the first ten years they will need little or no repairs; after that length of time, the wood above the mean level of the water may require general but inexpensive repairs for the preservation of the dikes in their proposed form. It is probable, however, that after the equilibrium between the current and the material composing the bottom is fully established, and the channel enlarged to the proposed dimensions, the banks formed by the deposits on the outside of the dikes will answer the purpose of guiding the water and will contribute to the maintenance of the channel. The gates, being constructed of galvanized iron and submerged timber, should last for many years, and the occasional repairs that may be required from time to time can be provided for at a small annual outlay. It is believed that when the channel has reached the dimensions proposed no further dredging will be needed, the scouring being sufficient for its preservation.

The method of improvement herein suggested has reference to the channel leading to the Yard only, in which it is supposed the mem-

bers of the Institute are particularly interested; but it may be proper to add before closing, that the benefits pointed out as likely to be derived by the Yard, as the result of the proposed works, may be made extensive to the Uniontown side of the river.

When the Yard channel has been enlarged to the proposed dimension, the subsequent work of the current will be to maintain the established equilibrium and prevent future deposits. Under those favorable conditions the scouring action of the current may be suspended for a limited time, and on being restored, the newly accumulated sediment will be at once swept out by the current, somewhat strengthened by reason of the reduced sectional area and the stable condition of the channel restored. It is evident therefore that if another channel be confined by similar constructions along the water front on the south bank of the river, a portion of the stored waters might be diverted from time to time, as circumstances require, from the main or Yard channel, and thrown into the other, where they would exert on the bottom a scouring influence greater in proportion to the reduced sectional area. In this manner the waters might be made to oscillate without any waste of power, to the great commercial and sanitary advantage of all concerned. Additional facilities would be offered by this combined system of improvement to the propagation of the flood tide through the south channel, and as the storing area of the basin would remain practically the same, a marked decrease may be expected in the flood current, with a proportional loss of sedimentary carrying capacity.

The two parallel broken lines along the south bank of the river indicate the probable location of that channel so as to best serve the purpose intended. It is supposed that a water-way 150 feet wide at the bottom and 10 feet depth at low water will be sufficient to meet the business interest on that side of the river for many years to come, and those are the dimensions estimated upon. The channel is laid on an easy curve in front of the town, and then by a straight line carried across the alluvial low land at Poplar Point. This is done in order not to interfere with the flood gates, and to avoid an abrupt bend around that point. After crossing Poplar Point the channel is taken by an easy curve into the main channel above Buzzard Point, a location which it would necessarily take by reason of the diverting influence of the flood waters proceeding from the flats to the south. Between Poplar and Buzzard Points the dikes will be kept at or below the level of mean tide, so as not to obstruct the flow of the

flood waters. The estimated cost of this improvement, including dikes, gates, probable dredging, &c., is $50,000, a very small amount when we consider the commercial and sanitary advantages to be derived therefrom.

NOTE.—Subsequent to the completion and reading of the foregoing paper, the report of a Board of Commissioners (appointed by the Hon. Secretary of the Navy in pursuance of an Act of Congress dated March 3d, 1827, for the purpose of establishing a plan for the improvement of the Washington Navy Yard) has attracted the attention of the writer.

While the river was frozen over, the depth of water, throughout the whole front of the yard—1700 feet in length by 500 feet in width—was very carefully measured by soundings through the ice every 50 feet. The depth is noted in a chart, signed by L. Baldwin, Engineer, and was submitted by the Board to the Secretary of the Navy.

On each of the first four diagrams herewith (Plate 11) are shown:

1. The outline of the bottom of the channel in front of the Yard wharf as represented in the chart prepared in 1828 under direction of the Commandant of the Station and the Board of Improvements.

2. The outline of the bed of the channel as shown by the Coast-Survey chart of 1842.

3. The outline of the channel bed as found by the survey of 1882.

On Fig. 5, the outline of the bottom of the channel as determined by the surveys of 1842 and 1882 are only given; the survey of 1828 not extending to that point.

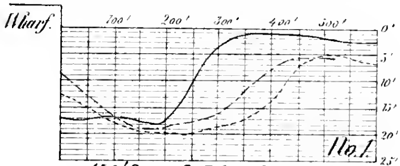
The depths have all been reduced to the same datum—mean low water—and as the line of the wharves has remained unchanged since the earliest survey, there can be no doubt that the widths and depths of water are correctly represented.

Again, as the dredging appliances in use during the first quarter of this century were very rude and ineffective, there can be no doubt that the sections found in 1828 represent the true regimen of the channel.

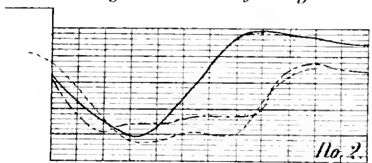
It will be seen that the survey of 1842 shows a considerable reduction in width and depth, while the chart for the present year indicates a most marked reduction, very nearly 45 per cent. in area since 1828, in front of the Yard, and 40 per cent. in front of the Saw-mill wharf

Plate II

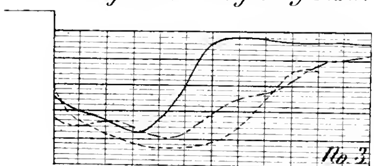
Cross Sections of the Eastern Branch Opposite the Navy Yard Washington plotted from Surveys of Yard Authorities in 1828. Coast Survey 1842 and Survey 1882. (Mean low water.)



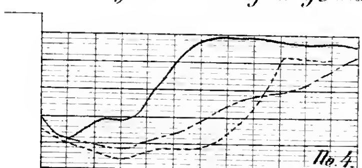
150' from S.E. Cor. of Navy Yard.



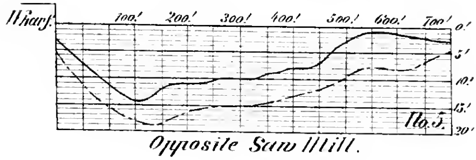
550' from S.E. Cor. of Navy Yard.



950' from S. E. Cor. of Navy Yard.



1250' from S. E. Cor. of Navy Yard.



Opposite Saw Mill.

———— Indicates Survey of 1882.
—·—·— " " " 1842.
- - - - - - " " " 1828.

Areas in a width of 500'.

	1828	1842	1882
Sec 1	7500	6410	4293
" 2	7383	6808	4477
" 3	7975	7227	4331
" 4	8340	7880	4090
" 5	.	8857	5276

A. FRIEDENWALD LITH. BALTO.

since 1842. It must also be borne in mind that from 1850 to 1869 the dredge was extensively employed in deepening and widening the channel, not only in front of the Yard, but all along where necessary, to the Arsenal, but since 1869 no dredging has been done.

The record of these surveys is submitted in proof of the assertion that the natural tendency is to a rapid silting and shoaling of the channel.

DISCUSSION.

CAPTAIN R. L. HOXIE, Corps of Engineers, U. S. A.

Mr. Chairman:—I have read with a great deal of interest the paper submitted by Mr. Menocal, but have not had time to consider the subject with that degree of care which its importance requires. My late arrival this evening prevented me from hearing the reading of the paper before the society, and I can speak only from the recollection of the impression made several days ago. At that time I saw nothing in Mr. Menocal's premises or conclusions to which I could take exception. The argument appeared to be sound and the plan quite feasible, with probable success. This evening, for the first time, I have examined the charts and diagrams explanatory of the contents of the paper, and these sufficed to renew the first impression.

I say this notwithstanding a violent prepossession in favor of *filling up* all tidal areas in close proximity to the city, and for this reason—Mr. Menocal's plan is one for the improvement of navigation without detriment to existing sanitary conditions. It will probably effect the improvement of navigation at a minimum of cost and within a reasonable time. This being accomplished, the problem of filling up these areas is advanced one step. The condition of *maintaining* the necessary channel to the Navy Yard takes the place of the present condition of *creating* and maintaining it. This condition is, of course, imperative if the Yard is to be preserved.

I have no reason to suppose that a closer scrutiny of Mr. Menocal's paper would compel me to challenge any of his conclusions.

CAPTAIN GEORGE W. DAVIS, U. S. A.

Mr. Chairman:—Mr. Menocal's paper has greatly interested me, and I believe will be regarded by engineers as a valuable professional contribution. His observations on the tidal action of the Anacostia are most instructive, and his verbal explanations of the maps and diagrams exhibited have been most helpful to a full understanding of the problem which he has studied so industriously.

It has long been well known that the duration of the ebb tide in the Potomac river near Washington much exceeded the flood, and taking into account the ordinary river flow, something like one hundred millions cubic feet of water for a single tide, it is naturally inferable that the tidal and fluvial currents combined would suffice to keep the channel free from sedimentary obstructions. But in considering the subject, account must be taken of the millions of cubic

feet of alluvium yearly brought down the Potomac from its water-shed, a large part of which is now denuded of the vegetation that once protected the land from wash. The effect of this deposition of sediment has been more marked over those wide areas known as the flats on either side of the main channel where the current is always more sluggish, than in the channel itself, but the weight of evidence tends to confirm the oft-repeated assertion that the channel depth is not only diminishing in certain places, but is also being reduced in width; a confirmation of this statement is furnished by comparing the channel dimensions shown on the Ellicott map published in 1792 with those of recent date. The flats in front of the city on both banks of the river have unquestionably been formed by the deposition of sediment.

The Anacostia branch of the Potomac is a wide and long basin into which the waters of the river flow, or back up, when the main stream is higher than the tributary, and so the silt carried in mechanical suspension is transported into what is in effect a receiving basin, not only for the sediment imported, but for that derived from its own limited shed. When in the course of ages all the flats within the tidal compartment known as the Eastern Branch shall have been raised to the level of high water, which must some time occur, the tidal movement will be limited to a narrow channel, which itself would also be entirely closed but for the fact of its being the outlet for the drainage of something like one hundred square miles, comprising the water-shed of the Anacostia. What dimensions this channel would take it is not possible to determine. It certainly would not be navigable for sea-going vessels.

The causes which are at work to produce these results have of course been active for ages, but they have certainly been much more active since the denudation and plowing of the hillsides over large areas of Maryland and Virginia, and these silt-producing areas are certain to increase as the timber is cut down and the waters are thus likely to become more and more turbid.

The conditions that obtain here may be likened to those seen in the Sacramento, which a few years ago was navigable far above the city of the same name for large steamboats, but through the system of hydraulic or placer mining on the tributaries of that stream, millions of cubic yards of silt have been carried into the river, and the depth of water all the way down to the bay has been greatly reduced. So marked has the shoaling become at the Mare-Island Navy Yard that the use of the dredging machine has already become necessary, where a few years since was ample water for the largest ships. In the tidal compartment of the Eastern Branch above Poplar Point there is still storage room for some 218 millions cubic feet of water, and room probably for an equal amount of silt below low tide.

Mr. Menocal's plan contemplates the unrestricted flow into the estuary, under the influence of the flood tidal current, of the quantity of water required to fill the reservoir, moving through a cross section of 11,000 square feet. Upon the turn of the tide he proposes to contract this cross section and permit the exit of the water only through the ship channel, having a sectional area of some 7300 square feet, and so produce an ebb current so much more rapid than the flood that it will scour and sweep out the silt in the channel, and prevent the deposit of that held in suspension.

It seems to me Mr. Menocal has demonstrated the practicability of accomplishing this result. His estimate of the expense involved in the proposed improvement appears reasonable; it is for the government to consider whether the navy yard shall be allowed to remain ineffective or the channel restored. It has been stated that there has here been expended for construction and maintenance upwards of $4,000,000.

The following named vessels of war have been built and equipped at this yard, viz:

Name.	Class.	Tonnage.	Built.	Maximum Draft.
Columbus,	Ship of the line,	2480	1819	25 feet.
Potomac,	Frigate,	1726	1821	22 "
Brandywine,	Frigate,	1726	1825	22 "
Columbia,	Frigate,	1726	1836	22 "
St. Louis,	Sloop of war,	700	1828	16 "
St. Marys,	Sloop of war,	958	1844	17 "
Minnesota,	Steam frigate,	3200	1854	24 "
Nipsic,	Steam sloop,	615	1874	

In addition to the above, many of our largest vessels have been extensively repaired and supplied with machinery and other equipments at this station.

MAJOR PETER C. HAINS, Corps of Engineers U. S. A.

Mr. Chairman:—Having been asked to give an opinion on the plan of improvement of the Eastern Branch proposed by Mr. Menocal, I will state that I have not had sufficient leisure to give the subject the study it requires; nor have I the results of the latest surveys made by Mr. Menocal at my disposal. In compliance with the above request, however, I will endeavor briefly to call attention to what appear to me, with the limited study I have given to the subject, its objectionable features.

The principle on which the plan seems to be based is, that the deposit of sediment is due chiefly to the action of the tides, the flood-tide taking in material which is deposited at slack water, and the lack of power in the ebb current causes it to remain in place: in other words, there is a constant tendency to silt up stream, and that this silting up process is likely in a time not far distant to fill up the present channel and flats, destroying the former for purposes of navigation, and rendering the latter a pestilential swamp. Whether the river be filling up as rapidly as is supposed can only be established by a comparison of reliable surveys made at various times. I have no very recent surveys with which the older ones may be compared. Consequently, the data at my disposal is not sufficient to form a correct idea of the present condition of the river.

That the deposition of sediment is going on will be admitted without question, but that it is going on with such rapidity that dredging is to be regarded as a costly and unsatisfactory method of improvement does not seem to be conclusively proven.

Mr. Abert made an estimate of the cost of dredging a channel 100 feet wide on the bottom, with slopes of eight base to one vertical, together with a basin

1250′ by 300′ in front of the Navy Yard, to a depth of 18 feet at low tide, to be $25,082. Dredged a depth of 20 feet at low tide, the cost would be $47,544. The estimated amounts of material to be removed in each case were 121,170 and 229,680 cubic yards, respectively.

A channel 18 feet deep at low tide will admit vessels drawing 20 to 21 feet at high tide, and a channel 20 feet at low tide will admit vessels of 22 and 23 feet at high tide. The above estimates were made from data furnished by the Coast Survey Chart of 1862, no later surveys being available. Mr. Menocal estimates the cost of a dredged channel to be $250,000, a sum vastly in excess of Mr. Abert's figures. This may be due partly to an increased deposit of sediment in the last few years, and a greater width and depth of channel to be dredged.

Unquestionably, a channel of the width proposed by Mr. Menocal is better than one only 100 feet wide, but is it necessary? A channel 3000 feet wide is better than one only 300 feet; but the benefits to be derived are not in proportion to the increased cost. In comparing the cost of a dredged channel with one made in any other way, the cost should be limited to the necessities of the case. I am not to be understood as necessarily favoring the dredging process. I only refer to it because I think Mr. Menocal, in comparing his plan with the plan of a dredged channel, has overestimated the cost of the latter.

I do not think Mr. Menocal has proved conclusively that the deposit of sediment is due to the silting up stream alone. May not other causes have been active in producing the present condition of the river? and if so, is it not hazardous to plan an improvement without giving them due consideration?

The difference in velocities of the ebb and flood currents may be only a partial cause of the present condition of affairs. The difference that exists between the surface velocities of the flood and ebb tides may not be found in the bottom velocities. On the other hand this difference may be greater or it may be less, and the error, if any, might be in favor of the plan or against it. The uncertainty of accuracy in the calculated bottom velocities is a strong argument, however, against a plan of improvement based partly, at least, on their calculated difference. It is not always safe, in a tidal stream, to accept as correct the bottom velocities deduced by formulas from observed surface velocities; the former are not unfrequently influenced by causes, the discovery of which baffles the most careful observer. A better way is to measure the bottom velocities themselves, and as this is a task by no means difficult, at least approximately, it should be done to establish, with certainty, the accuracy of the premises on which the improvement is based. In order to modify the action of the forces of nature now in operation, so as to utilize them in any plan of improving navigation, it is important to get clear and precise ideas of their present action. I do not say that the calculated bottom velocities referred to may not be correct, but I do say it would have been better to have determined them by observation rather than by calculation.

Again, the dike proposed will undoubtedly prove to be some obstruction to the movement of the flood tides; it may not be great, but that it will be felt in a measure, at least, is certain. It will be impossible to locate the dike so that at all places it will conform to the direction of the current. This current

doubtless varies its direction at different stages of the tide, and if the direction of the current be changed, changes in the regimen of the stream may be brought about that are neither contemplated nor desired.

Supposing, however, that the premises on which the plan is based to be correct, that the deposit is due to the causes stated, that these causes are still in operation, the following objections occur to me :

The construction is too light. A dike built of 3″ plank would be in need of continual repair—something more substantial would be necessary. One severe winter would be apt to demolish it, or at least damage it to such an extent that practically it would have to be rebuilt in the following spring. The inlet gates being of light construction, will also be liable to damage at all times from drift logs and other floating bodies.

There does not appear to be sufficient power in the automatic apparatus to operate the gates with facility and certainty at all times; grass, weeds and sticks will become entangled in the leaves and prevent their proper working, or necessitate the services of a man to keep the apparatus in order. At night, considerable difficulty would be found in doing so. The bearings, being of iron, would rust, and considerable power would be lost in overcoming the friction. I am not sure that sufficient reserve power is contained in the automatic apparatus to overcome this difficulty. During the winter the gates could not be operated at all. The ice that would form on the leaves would render their working difficult, if not impossible, and that which forms in the float-chambers would stop the working of the floats. It would, perhaps, become necessary to remove the gates entirely during one-fourth of the year, for this reason.

The above objections are not of such a nature that one can say the plan is not practicable, provided further investigation established the accuracy of the premises on which the plan is based; they point rather to the necessity of modification in construction, and show that the estimated cost of a plan of improvement that does not take these matters into consideration is defective and too low.

It is estimated that the piers and tanks from which the gates are to be suspended and worked interpose an obstacle to the flow of water as great as one-seventh the cross-section of the river on the flats, and that no higher velocity of the flood current may be apprehended than exists at present. But may we not expect a reduced velocity on the flats below the gates? An obstruction of one-seventh the area across the flats is a matter of some consequence, and while the velocity of water flowing through the gates may not be perceptibly increased, a retardation below will be apt to occur. In point of fact, however, I am of the opinion that the gates and the dam will obstruct much more than one-seventh the cross-sectional area, if built of the proper strength to insure stability, and this obstruction will be certain to produce a retardation of the current at some distance below the gates. We have a case similar to this in the main branch of the Potomac above Long Bridge. Since the bridge was built, dredging has become necessary every few years to keep open a navigable channel. The effect of this retardation of the current below the gates, and the increased amount of material scoured out from the channel on the ebb

tide and held in suspension, will accelerate the deposit on the flats, which we are informed is already rapidly going on. The material scoured and carried out on the ebb tide will be dropped again as soon as the velocity of the current is sufficiently reduced. This reduction will take place immediately after the water escapes from its confined area between the dike and the shore. Some of it will doubtless be carried out beyond the mouth of the East Branch and deposited elsewhere, perhaps to the injury of some portion of the main river, while much of it will be dropped on the flats below the gates. The works thus intended for the improvement of navigation will bring about a sanitary condition of the flats worse than ever before. The reduction of the depth of water on them will be accelerated, and finally the flats will become too shoal to pass a sufficient amount of water over them, on the flood tide, to be of any use on the ebb. The gates will thus become useless and the improvement a failure unless dredging be resorted to. We would then have the flats to dredge instead of the channel. When it is a question of dredging, the general opinion will be that it will be found more satisfactory and economical to dredge the channel than to dredge the flats.

It is already claimed that the flats of the Eastern Branch will have to be reclaimed from overflow, as a sanitary measure, at no distant day; that they have already approximated to that malarial condition necessitating it. While I do not admit or deny, at the present time, the truthfulness of this statement, I do admit that it may become necessary, at some future time, to adopt measures to prevent their overflow at high tide. Hence, in planning any improvement for the navigation, due regard must be paid to its possible effects on the sanitary condition of the flats. If it should tend to render their condition worse than they will become by the operation of natural causes, or if the plan does not admit of the possible necessity of reclaiming the flats from overflow at any future time, it should not be adopted.

Civil Engineer S. T. Abert.

Mr. Chairman:—I would like to ask Mr. Menocal one question in reference to those curves: whether it is safe to base his theory upon surface velocities for determining the direct tidal power and the difference of the tides?

The surface velocity does not afford a certain guide to determine the sub-surface velocities.

The velocities in the vertical section sometimes conform to a parabola, or an ellipse, often they vary from these curves even in a river purely fluvial. But in a tidal river the velocity at the surface is often flowing down stream when the sub-surface velocity is in the contrary direction.

Civil Engineer A. G. Menocal, U. S. N.

Mr. Chairman:—I will briefly reply to the interesting remarks of Major Hains, touching only on those points in his discussion which I believe to be based on a misapprehension of the facts, or on which we widely differ in our conclusions.

Skilled and experienced naval officers are of the opinion, that considering its tortuous course and tidal current, the channel leading to the Yard cannot

satisfy the requirements of the Station with a width of less than 250 feet from the Yard to its junction with the channel of the Potomac, and at least 325 feet wide in front of the Yard, with a mean depth of 20 feet below the plane of low water. Under the present condition of the river, a channel of those dimensions, together with the necessary excavations in the slips, would involve about one million of cubic yards of dredging, which, considering the difficulties attending the disposition of the material, cannot be estimated at less than $250,000. Should the width be reduced to 300 feet in front of the Yard, and 200 feet from the Yard to the main river, the amount of material to be excavated would be 692,011 cubic yards, and its estimated cost $173,000, or $73,000 in excess of the estimated maximum cost of the improvements I have proposed. A channel of smaller dimensions will fail to meet the needs of the service.

If other causes than those adverted to are actively at work in producing the present condition of the river, they have not been discovered, and any suggestion specifying those causes or influences would have been received with favor as a basis for further investigations.

It is with the present condition of affairs that I have had to deal in these investigations, and actual conditions, as I see them, have determined my conclusions, the correctness of which have been established by comparing the last survey with others made many years earlier, as shown in the diagram illustrating the note accompanying the original paper. I admit that it would have been very interesting to obtain by actual observation, at least approximately, the bottom velocities; but I cannot perceive in what manner the results obtained could have materially altered the premises established or the conclusions arrived at. The calculated bottom velocities, deduced from the observed surface velocities, were used in the discussion intended to show the relative scouring power of the tides, and whatever error might be involved in the application of the formula employed, it was common to both tides, its effect was eliminated in the operation and could not alter the result. Observations for bottom velocities demand much labor, and the results are at best uncertain. However satisfactory any effort in that direction might have been, it would have proved of little or no practical value in designing the new channel, or determining, even approximately, the probable bottom velocity as deduced from an assumed surface velocity. For that purpose I would, most certainly, follow the practice of the most eminent hydraulic engineers, and adopt one of the formulæ established by recognized authorities on the subject.

Major Hains correctly states that it is not always safe in a tidal stream to accept as correct the bottom velocities deduced by formulæ from observed surface velocities, and that the former are not unfrequently influenced by causes, the discovery of which baffles the most careful observer. This remark probably refers to the undercurrent observed in some situations within the influence of the tide, such as the river Dee at Aberdeen, and the Cromarty Firth; but these phenomena, although somewhat obscure, have generally been traced to the configuration of the bottom, a marked contraction at the entrance of the estuary or river, or a decided difference in the density and temperature of the tidal waters; conditions which do not obtain in the present case.

The dike has been located so as to conform to the direction of the flood current, as marked by the present channel and the current observations taken for the purpose, and I can see no reason for apprehending any injurious obstructions by it to the propagation of the flood tide.

Major Hains asserts that the construction is too light, and that something more substantial is necessary. On this point I must differ with him, especially in reference to the dikes, which I regard as amply strong, and fully able to answer the purpose intended. In relation to the gates, it will be observed that the system suggested and estimated upon was not presented as final, but only as one of the many solutions of the problem. It was then intimated that although the problem was a complicated one, the difficulties involved were not of a nature to defeat the proposed improvement. If the system was applicable in other respects, no such obstacle would be permitted to stand in the way. Another system less objectionable might now be suggested, but it would be out of place in these remarks.

It may be proper here to call attention to the fact that the system of tidal basins designed by the late Major Twining, in connection with the improvement of the Washington harbor, was endorsed by a board of engineers, and later by Major Hains, before a system of flushing gates had been decided upon.

I will not attempt to reply to objections raised as to the power of the proposed automatic apparatus to overcome the resistance and operate the gates at all times. Ample margin was allowed in the original calculation for the purpose of arriving at an approximate estimate of cost; but that is a matter of detail to be definitely settled at the proper time.

It is evident that the ice may interfere, at short intervals during the winter, with the regular operation of the gates proposed; but this can easily be overcome by removal of the moving slats, to be again replaced when the conditions are favorable. Such an operation would not require much labor or present serious difficulty, and as to the temporary suspension of the system of improvement, it cannot materially affect the efficiency of the channel. During the winter months the tides are low and the water usually clear, and any accumulated sediment would be rapidly removed as soon as the stored waters were properly directed into the channel. It may be proper in this connection to state that during the winter of 1881–82, and the present winter to this date, there has not been one day in which the operation of the gates would have been interrupted by obstruction from the ice.

The possibility of an interruption in the operation of the gates arising from floating grass, weeds and sticks has, I think, been overestimated. The water flowing through the gates proceeds from the main river, and will be comparatively free from such obstructions.

The present sectional area of the river on the line of the gates is 9011 square feet, and that of the proposed channel 11,066 square feet, or an increase of about 23 per cent. This will bring a proportional decrease in the velocity of the flood current, and admitting, as has been stated, that an acceleration of the current will take place at the gates, and a proportional retardation below them, the sluggishly moving waters will not possess a scouring or sedimentary carry-

ing capacity to produce the deposit now taking place. The injurious effect produced by the construction of the Long Bridge should not be presented as an illustration of what may be expected as the probable effect on the flats of the Branch if the proposed improvements were put into execution. At the Long Bridge no provision was made to compensate for the large reduction of sectional area involved in its construction, and the consequences have been such as might well be expected.

The depth of water on the flats of the Eastern Branch has been slightly reduced since 1842, but it is contemplated that with a reduced flood current and an acceleration of the ebb flow the depositing process will either be stopped altogether or reduced to such small limits as to cause no material reduction in the tidal prism, for an indefinite length of time. It is unquestionable that the material scoured and carried out on the ebb tide will be dropped again as soon as the velocity of the current is sufficiently reduced, but I do not admit that the deposition will be injurious to the flats below the gates. The scouring process will be dependent upon and increase or diminish with the ebb current. During three hours and fifty minutes of the ebb flow the current will have sufficient power to act on the material composing the bottom, and the confined waters, being thrown into the Washington channel where the increased volume will cause a proportional increased acceleration, the material held in suspension will be carried down the main river to the sea, or be deposited on flats and in coves, where it can do no harm. As the velocity slackens, so will also its scouring power, and when it has been so much reduced as to be inoperative on the bed of the stream, it will yet be running with sufficient speed to carry forward into the main branch of the river the remaining material in suspension. When the waters cease to flow and the last of the ebb is spread over the flats at the mouth of the Branch, the water will be free of scoured sedimentary matter. In any event, the proposition that the flats may become too shoal to pass a sufficient amount of water over them, on the flood tide, to be of any use on ebb, and that as a consequence thereof the gates will become useless unless dredging is resorted to, is, I believe, totally inadmissible. No engineer in charge of the work should allow such a state of affairs to take place, and if, through lack of proper vigilance and foresight, sedimentary matter be permitted to accumulate as predicted, and bad comes to worse, he should not resort to dredging as a means of removing the deposited material, when a diversion of the ebb waters over the flats and through the gates would readily accomplish the desired result, without much expense, and in a comparatively short time. One or two ships anchored across the main channel would divert the water without any cost.

That the flats of the Eastern Branch may have to be reclaimed as a sanitary measure I will not admit or deny. What the remote future may bring to us is not at all easy to foresee, but I do claim that the proposed improvement will materially improve the present sanitary condition of the city, especially that portion adjoining the Anacostia river, and that the benefits derived therefrom will have fully justified any possible expenditure in connection therewith, before the reclamation of the flats is seriously considered.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

PROF. CHARLES E. MUNROE, U. S. N. A.

No. III.

Berthelot and Vieille have continued their investigations upon the explosive wave, and have given their results in the *Comptes Rendus*, **95**, 151, July 24, 1882, under the title *Nouvelle recherches sur la propagation des phénomènes explosifs dans les gaz*, and on 199, July 31, 1882, under the title *Sur la période d'état variable qui précède le régime de détonation et sur les conditions d'établissement de l'onde explosive.* They find that the velocity of propagation for each inflammable mixture is a true specific constant, and that it is quite important to know what this is, both as regards its bearing on the theory of the movement of gases and as concerns its applications in the use of explosives. Hence they have determined the constant for a large number of substances and mixtures, and the results given are the mean of repeated observations. By means of Clausius' formula previously given,† they have calculated the theoretical velocity for each case, and the measured velocity closely corresponds with this, except where carbon monoxide is used, and where cyanogen is mixed with two volumes of nitrogen and ethylene with four volumes of nitrogen. When hydrogen is mixed with an excess of nitrogen there is also a marked retardation. The velocity of translation of gaseous molecules, which retain the total energy developed by the heat evolved by the reaction, may be regarded as a limit that represents the maximum velocity of propagation of the explosive wave. But this velocity is diminished by contact with foreign bodies; also, when the mass inflamed at first is too small and too rapidly cooled by radiation; and when the initial velocity of the chemical reaction is

* As it is proposed to continue these notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications, trade circulars, or expert testimony in infringement cases.

† Proc. Vol. VIII, p. 303.

too feeble, as is the case with carbon monoxide. Under these conditions the wave is retarded and even stopped; then the combustion propagates itself from side to side, following a slower law.

The apparatus used in these experiments was extremely delicate. The electric spark which excited the detonation, and the exceedingly light piston which received the blow at the other end of the tube, were both connected with a chronograph, which was turning at the rate of fifteen metres per second, and thus the $\frac{3}{100000}$ of a second could be measured. In addition to the experiments mentioned above, others were made by altering the position of the piston in the tube for six positions intermediate between 0.02 metre and 40.43 metres. It was found that the limit of combustibility changed with the energy of the spark; that as combustion goes on the energy may increase so that detonation results; that this can only take place when the layer of inflamed particles exerts the greatest possible pressure on the layer in contact with it, and that it is then that the inflamed gases possess the maximum energy and velocity of translation. It is possible that analogous circumstances may conspire to give to some explosions of fire damp an unusual velocity of propagation and degree of violence. The agreement between the calculated and measured velocity of the explosive wave shows that dissociation plays an unimportant rôle in these phenomena, probably because of the high pressure developed in the path of the wave, and because, also, of its brief duration.

Where these conditions exist, viz. a powerful initial cause; a sufficiently rapid chemical reaction between the gaseous constituents; a sufficient number of particles are inflamed at first to inflame the adjacent particles; the mass of the gas is so large as not to lose a marked quantity of heat by radiation; and the layer of inflamed particles exerts the greatest possible pressure on the layer of particles with which it is in contact; there we have the *dominion of detonation.* But it is easy to conceive of a totally different set of circumstances where there is a tendency to reduce to zero the pressure which the inflamed layer exerts on its neighbor, and consequently the velocity of translation of the molecules; then their energy and the heat they contain will also be reduced. In such a system the heat will be almost completely lost by radiation, conduction, contact with surrounding bodies, and inert gases, etc., with the exception of the very small amount which is essential for raising the neighboring particles to the ignition point. This is the *dominion of ordinary combustion*, and it is this which Bunsen, Schloesing, and Mallard and Le Chatelier

have studied. Of course we may have intermediate states between these.

These two states and the general conditions which define each, and their transition into the other, apply not only to gaseous mixtures, but also to solid and liquid explosives which are transformed wholly or in part into a gas at the moment of detonation.

In the *Comptes Rendus* **95**, 599, October 2, 1882, Mallard and Le Chatelier continue their accounts of the investigation of the vibratory movement of flame in gaseous mixtures, in a paper entitled, *Sur la nature des mouvements vibratoires qui accompagnement la propagation de la flamme dans les mélanges gazeux combustibles.* They used the apparatus described in their previous paper,* with one end open, but they registered the progress of the flame by photographing it on a revolving cylinder, covered with sensitized paper, the rate of revolution being known, and the mixture of gases used being such as would emit sufficient actinic rays when burning. The result showed that for the first quarter of the tube the propagation was uniform, and that from that point it increased in speed, and that the regularity, duration and amplitude of the oscillations varied from point to point. The undulations took the form of sinusoïds indicating a simple vibratory movement, or more complex forms, showing the superposition of several such movements. The mean velocity of propagation appears to be accelerated as the amplitude and rapidity of vibration become greater. In one experiment the explosive wave of Berthelot and Vieille was produced, and the last part of the tube was completely pulverized. The brilliancy of the flame varies with the successive phases of a vibration.

The *Journal Chem. Soc.* **237**, 920, September, 1882, abstracts from a paper by Mallard, in the *Chem. Centr.* 1882, 268, on the "Danger of Gas Explosions," in which measurements of the rate of ignition in mixtures of common gas with air, and marsh gas with air, were made, confirming the results given above. He shows that there cannot be any danger from explosive mixtures travelling back in the pipe.

Under the title *Recherches sur l'emploi des manomètres à écrasement pour le mesure des pressions développées par les substances*

* Proc. Nav. Inst. VIII, p. 303.

explosives, Sarrau and Vieille have contributed a series of articles to the *Comptes Rendus* **95**, 26, July 3, 130, July 17, 180, July 24, '82, in which they consider the use of Noble's crusher gauge for determining the pressure developed by the high explosives. They use *copper* cylinders, and by means of a machine similar to Rodman's, they exert a slow and progressive pressure upon the cylinder until it will support a determined load without permanent deformation, and thus determine the resistance of the cylinder for each given amount of compression. The examination of the results obtained shows that when the force exerted is between 1000 and 3500 kilos, its value may be expressed by a linear function of the compression.

By the aid of this data they deduce for the pressure the formula

$$p = k_0 + \frac{k\varepsilon}{1 + \varphi\left(\frac{\tau}{\tau_0}\right)}$$

in which

k_0 and k = two constants.

ε = the compression shown by the cylinder.

τ = the time between the origin of the movement and the production of the maximum force.

τ_0 = the duration of the compression of the cylinder by a constant force acting, without initial velocity, by means of a piston having a mass equal to m.

φ = a function which is equal to zero when the variable is zero, but increases rapidly when the variable increases.

The value of p for a measured value of ε depends then upon the ratio $\frac{\tau}{\tau_0}$. This ratio is the variable characteristic of the phenomena, and it is necessary to know it for each special case as precisely as possible.

The value of τ_0 is given by the formula

$$\tau_0 = \pi\left(\frac{m}{k}\right)^{\frac{1}{2}}$$

The value of τ is determined by a delicate instrument. This consists of a crusher gauge attached to the side of the vessel in which the explosion takes place. The piston of the gauge carries a pen which comes in contact with the smoked paper of a chronograph, to which is also affixed a vibrating fork for marking the time. This apparatus will record phenomena which occupy only the $\frac{3}{10000}$ of a second, as with some of the high explosives.

With this apparatus they find for gunpowder with a *density* of charge* of .7, a pressure of 3574 kilos per square centimetre.

The decomposition of potassium picrate in the state of powder was so rapid that τ could not be measured, but it was recorded when compressed blocks were used. For a *density of charge* of .3 the pressure was 1985 kilos.

Gun-cotton exploded so rapidly that τ could not be measured, and an increase in the mass of the piston produced no effect.

Dynamite decomposed more slowly than either gun-cotton or picrate of potash, and the value of τ varied with the mass of the piston. With a piston of 4 kilos, and a *density of charge* of .3, the pressure was equal to 2547 kilos per square centimetre.

The value of this method of investigation is shown in the fact that when a piston of 59.7 grammes was used for both dynamite and potassium picrate, and when the *density of charge* was .3 for each, the copper cylinder was compressed equally by each; yet it is found that for a *density of charge* of .3, the maximum pressure is 2547 for dynamite, while it is only 1985 for potassium picrate.

Commander Allan D. Brown, U. S. N., contributes a very readable article entitled "Explosions and Explosives," to the *Popular Science Monthly* **21**, 6, 773, Oct. 1882. Passing over the popular descriptions of the methods of preparation and characteristics of the different well-known explosives, we quote what he says concerning gum-dynamite or explosive gelatine, since he has recently had unusual opportunities for becoming familiar with this new explosive.†

Collodion gun-cotton is finely shredded, generally by hand, and placed in small quantities at a time in the nitro-glycerine, which is kept at a temperature of 80° F by means of a water-bath, the whole being constantly stirred with a wooden spatula; the proportion of materials is seven per cent. by weight of the gun-cotton to ninety-three per cent. of the nitro-glycerine. The latter dissolves the former, and the result is an elastic, gelatinous, semi-transparent mass, which is easily cut or torn apart, and shows no trace whatever of nitro-glycerine on handling. Its explosive properties are unaffected by contact with water, and in this respect it is the most useful of all the high explosives for military purposes. With the change in the physical condition of the two components comes also a change in

* Proc. Nav. Inst. Vol. VIII, p. 441.

† *Vide* Proc. Nav. Inst. Vol. V, p. 21, and Vol. VII, p. 473.

the ease of explosion; these two bodies, each of itself highly explosive, form when united one which is quite the reverse. When unconfined, a primer of fifty grains of fulminate will cause the explosion of but a very small portion of a charge, the rest being torn in pieces; if, however, it be strongly confined, so that the blow of the fulminate exerts its whole force, which is propagated through the gelatine, it then explodes with a violence as great as that of nitro-glycerine, if not somewhat greater. This latter point has not been fully determined, but the probabilities are that the expansion of the constituents of the gelatine is more complete and is accompanied with more heat than is the case with nitro-glycerine alone. The gelatine freezes at 40° F., and in this state is fired with no difficulty whatever, being in this respect much superior to dynamite. When subjected to a pressure of two hundred and fifty pounds to the square inch, no nitro-glycerine is separated; the union between the two constituents seems to be complete and definite. If subjected to the action of flame it takes fire less readily than dynamite, but burns very much like it, with perhaps a greater strength of flame, as if urged by a bellows. When heated to 100° it softens, but does not become at all greasy, and there is no exudation of nitro-glycerine. Explosion by the application of heat takes place at about 420°; but it is found that by the addition of a small amount of camphor, say four per cent., it will bear an increased heat of 100° before explosion. Experiments made with the gelatine thus camphorated show that the camphor exercises no deleterious effect upon the strength of the material, while rendering it less like jelly, and more like that form of confection known as fig-paste. Six per cent. of camphor may be added without harm, but any greater quantity materially diminishes the explosive effect. Portions of this gelatine, both pure and camphorated, have been subjected to a constant heat of 100° for more than six weeks, and no exudation of the dangerous nitro-glycerine has been observed. It will not explode under circumstances which ordinarily render certain the detonation of either nitro-glycerine or dynamite, that is to say, a quantity of gelatine will resist the shock of the detonation of another quantity placed within a few feet of it; if very near it may take fire and burn, but detonation will not ensue unless the two masses are almost in actual contact, and even then it will not always occur. It further possesses the property of permitting the impact of a ball from a gun without exploding, while both dynamite and gun-cotton may be readily detonated by a blow of this kind. All these tests tend to show

that it possesses in a high degree the elements desired in the ideal high explosive for military purposes, if not for commercial use.

So much difficulty was encountered in the first attempts at the construction of a suitable primer for its explosion, that it seemed doubtful whether it would ever be a practicable material, as it was thought that nitro-glycerine must be used to accomplish the desired result. Subsequent experiments conducted in this country have shown, however, that a dry gun-cotton fuse with a fulminate cap, containing twenty-five grains, will fire the gelatine with ease and certainty, even when unconfined. The problem so long confronting the manufacturer of explosives would seem to be nearly solved; the requisites of greater power in small compass, of permanency when subjected to tropical heat, of ease of firing when but slightly confined, of safety from the explosion of neighboring masses of the same or on being struck by a projectile, and of not being affected injuriously by water, all seem to be fulfilled by this agent in a manner more complete than by any other.

If it should be found that a long-continued exposure to heat tends to produce decomposition, as may prove to be the case, greater care in the preparation of the materials from which it is manufactured will probably overcome this difficulty, and it will then bid fair to supersede gun-cotton for very many purposes, if it does not altogether take its place.

Through the courtesy of the author we have received a copy of a *Report on Vigorit Powder*, by Lieutenant W. R. Quinan, 4th Artillery, U. S. A., general superintendent of the California Vigorit Powder Company, and we take pleasure in commending the report as greatly superior to those generally issued by manufacturing companies, since it possesses real technical value. The methods employed for testing the strength of the powders, though not wholly new and somewhat rough, are quite ingenious and sufficiently trustworthy for the object in view. The iron plate and éprouvette tubes were discarded as delusive or as being advantageous to slow-burning powders, and a simple form of the "Crusher Gauge," with lead cylinders, was employed.* This gauge consisted of a heavy iron base, supporting four vertical wrought-iron guides, which were connected at the top by a ring. The lead plug is placed on the base, a piston weighing 12¼ lbs. rests on the plug. The top of the piston is hol-

* Henry S. Drinker, On Tunnelling, p. 77.

lowed out to receive the charge, and over this is placed a 34½ shot of tempered steel. The shot is bored through its axis to receive a capped fuse. All these parts are between the guides, and when the charge is fired the piston is driven against the plug, while the shot is thrown out in the opposite direction. To determine the pressure exerted in compressing the plug a given amount, a foot-pound machine was constructed similar in form to a pile-driver with a graduated scale, the shot of the pressure gauge serving for the hammer and the piston of the gauge for the anvil. This form of apparatus realizes more perfectly than any other the conditions which exist when explosion takes place in a confined space. Tests were made of cast and drawn lead plugs. The cast lead ones were unsatisfactory, while the drawn ones gave very regular results. An apparatus similar to the foot-pound machine was used for testing the sensitiveness of the powders to percussion, and, with the addition of a gas pipe and wooden tamping rod, to tamping. With this tamping apparatus the vigorit powder, as now made, withstood more than a dozen blows of 300 foot-pounds each. The ability to tamp a powder is regarded as quite important, since it enables the miner to put the powder where it will do the most efficient work, hence a powder which can be tamped freely will be found more economical than one which is too sensitive to be tamped at all.

The friction apparatus consisted of a heavy block covered with sand paper, resting on a board covered in a similar manner. By means of a long handle the block could be drawn backward and forward. The relative leakage of nitro-glycerine from the various powders was determined by placing equal weights upon weighed slips of bibulous paper for equal times, and then measuring the increase in weight of the papers.

Tests as to the effect of fire were made by ramming vigorit powder into an iron pipe until the pipe showed signs of yielding under the pressure. One end of the pipe was stopped by a wooden plug tightly driven in, and the open end was lighted by a match. The powder burned without explosion. Again: a large cartridge was placed in a small strong box, the lid being securely fastened with screws. A fuse, passing through a small hole in the side of the box, served to light it. The cartridge burned up without explosion, the box being badly charred on the inside, but not broken.

Lieutenant Quinan regards the property of deliquescence as a most serious one in mixed powders. The progress of deliquescence is

thus explained. The air confined in the cartridge contains a slight quantity of moisture, which, in uniting with the salt, causes a depression in temperature, which condenses fresh moisture from the surrounding air. This being taken up, reduces the temperature still more and brings a fresh supply, and so on. The process continues till arrested by an outside elevation of temperature, when the action is reversed. In losing moisture, the heat rendered latent is given out, raising the temperature, which causes a fresh loss of moisture and further elevation of temperature, and so on, till a change in atmospheric conditions arrests this process and induces a contrary. This gives two different and incompatible characters to a powder in which deliquescent salts are used, depending upon the particular state in which it is taken; when absorbing moisture it is comparatively weak and insensitive to blows or compression; when losing moisture it is comparatively strong and very sensitive to both. The temperature being already elevated, a slight blow will raise it to the exploding point. The compression given by the tamping rod in compacting it in the bore-hole may be sufficient to cause a premature explosion. These qualities render the powder unfit to bear climatic changes, and especially dangerous in warm or drying weather. Its constant subjection to chemical action gives it a character of instability especially conducive to disasters in handling it. The powder which is safe to-day and dangerous to-morrow is the most dangerous of all.

The effect of heat on all powders is to bring them nearer their exploding points, and thus to increase their sensitiveness. This heat makes a slight saving of work in explosion—so that all explosives are a little stronger in warm weather. The danger of deliquescent ingredients is not in lowering the firing point of nitro-glycerine, but of elevating the temperature of the powder to a dangerous approximation to this point.

The author holds that while in dynamite, the absorbent being inert, the force is dependent upon the amount of nitro-glycerine present, the more modern powders do not depend entirely on this. Citing the experiments of Roux and Sarrau, which showed that if a fulminate acted through the medium of nitro-glycerine an explosion of the first order would be produced, he argues that a mixture of nitro-glycerine with the ingredients of gunpowder will develop a much greater force than the sum of the forces of the two fired separately. In this he differs with Hill and Mowbray, while he is supported by Drinker. He also claims that anything in a powder which interferes

with the transmission of the detonating impulse or wave will cause a diminution in strength through imperfect detonation. It requires 60 per cent. of nitro-glycerine to make a powder of kieselguhr which can be depended upon to explode at all. As the nitro-glycerine is increased the strength increases rapidly, through better transmission of the impulse. Even taking 75 per cent. as the utmost which the powder will safely hold, the detonation is not perfect under ordinary conditions, though it approaches it more nearly as the impulse is concentrated by stronger confinement.

The name of this powder illustrates the different uses to which a name is put in commerce. Formerly the name Vigorite was applied to the nitrated cane-sugar discovered by Sobrero. In the last number* of these Proceedings the composition of a powder called Vigorit was given. The powder of the same name reported on by Lieutenant Quinan has still a different composition.

One of the results of modern activity in chemical research has been the discovery and recognition of the existence of many groups of substances, each member of which is composed of the same number of the same kind of elements, and possesses the same molecular weight, while the properties of the different members of the group are quite unlike. Such substances are called *isomeric* bodies. Again, other groups of bodies have been noticed which, while having the same percentage composition, possess in the higher members of the series a molecular weight which is a definite multiple of the lowest member of the series. Such substances are called *polymeric* bodies. The fact that these bodies exhibit different properties while having the same percentage composition, is explained by chemists as being due to a difference in the arrangement of the atoms in the molecule. It is a matter of great importance and interest to discover what this arrangement is, and this work now engages the attention of many chemists; but it can readily be seen that it must be surrounded by considerable difficulty, since we aim to learn the order of arrangement of inconceivably small atoms in not much larger molecules. This is reached, where it has been done, by a study of the reaction between the substance under consideration and other substances, and of the products of the reaction, and of its derivatives and replacement products, also of the various methods of production. Again, its various physical properties have been carefully studied. Through

* Vol. VIII, p. 444.

the consideration of the results of all these methods a knowledge of its constitution has been gained.

Mercuric fulminate belongs to such a polymeric series, which may be represented for the silver salts by

$AgCNO$	Silver cyanate.
$Ag_2C_2N_2O_2$	" fulminate.
$Ag_3C_3N_3O_3$	" cyanurate.

Mercuric fulminate was discovered by Howard in 1800, but the composition remained unknown until 1824, when Liebig analyzed it and the silver salt, and got a percentage-composition agreeing with the above formula, and in this he was confirmed by Gay-Lussac. They both agreed on the formula for the silver salt, and consequently for the mercury salt also, of $Ag_2C_2N_2O_2$, since silver cyanate was already known to have the simpler formula. Berzelius considered the fulminates as containing a metallic nitride (*e.g.* AgO, AgN, C_4NO_3) as this afforded an explanation of the fact that in many reactions, as with fulminating silver, only half the metal is separated. The detonation was attributed to the metallic nitride. Owing to the formation of the fulminates through the action of nitric acid and alcohol, together with the fact that they were explosive, induced Laurent and Gerhardt to regard them as compounds containing nitryl (NO_2), since nitric acid frequently introduces this radicle into organic molecules, and this often imparts to them an explosive character. Kekulé's study on the products of decomposition of fulminating mercury, and Schischkoff's on fulminuric acid, support Laurent and Gerhardt's views, and Kekulé writes the formula in accordance with these results thus $C(NO_2)(CN)H_2$. According to this, fulminic acid and the fulminates belong to the same type as marsh gas, thus

$CNCHHH$	Methyl cyanide.
$CNC(NO_2)Ag_2$	Silver fulminate.
$CNC(NO_2)Hg$	Mercuric fulminate.

Schischkoff doubles these formulas for the fulminates, but otherwise agrees to them.

From the abstracts *Jour. Chem. Soc.* **237**, 816, August, 1882, we learn that E. Carstanjen and A. Ehrenberg publish in *Jour. Prak. Chem.* [2] **25**, 232, a paper on mercuric fulminate, in which its action toward a large number of chemical agents is noted, and certain deriv-

ative fulminates described. When treated with various acids it was decomposed with formation of a mercury salt, carbon dioxide and a *hydroxylamine* salt. With hydriodic acid ammonium iodide was one of the products, and with boiling dilute sulphuric acid mercury *oxalate* was formed. A number of experiments were made to determine which form of cyanogen exists in mercuric fulminate, but the results do not yet seem to lead to an issue.

In a paper in *Comptes Rendus*, **94**, 1114, April 17, 1882, entitled *Sur quelques réactions des sels de protoxyde d'etain*, A. Ditte describes the formation of silver meta-stannate ($5SnO_2.Ag_2O$), which has a red color, and detonates, when heated, with the development of heat and light. This detonation is transmitted along a train of the compound, as in the case of gunpowder.

An experiment described by A. Villiers, *Comptes Rendus*, **94**, 1122, April 18, 1882, under the title *Sur le bromure d'éthylène tétranitré*, shows, very curiously, how limited the conditions are under which explosion may take place. He mixed ethylene bromide in a retort with about an equal volume of fuming nitric acid, and heated the mixture, when an energetic reaction took place, and oxides of nitrogen, nitrosyl bromide, and bromine were evolved. At first the ethylene bromide dissolved in the acid, but after a time the liquid became turbid and separated into two layers. At this point the reaction became explosive, and the lamp was withdrawn and the retort cooled by cold water. The liquid was afterward distilled almost to dryness, but *when the lamp was withdrawn and the temperature of the mixture consequently lowered, the reaction again became explosive.* The result of the reaction is the formation of tetranitroethylene bromide, which is obtained as canary-yellow crystals, which when heated to 145° detonate (mercuric fulminate detonates at 186°), but do not explode by percussion.

M. Vieille presents a paper to the *Comptes Rendus*, **95**, 123, July 17, 1882, entitled *Sur les degrés de nitrification limites de la cellulose*, in which he shows that the degree of nitrification depends upon the strength and amount of the nitric acid present, and the length of time (in most cases) the cotton is exposed to its action. He used pure nitric acid of different measured strength, and immersed the cotton in it at 11°, 100 to 150 times as great weight of nitric acid

being taken as of cotton used. The amount of nitrogen contained in the product was then determined by Schloesing's method. With nitric acid sp. gr. 1.450 the mononitrocellulose was obtained yielding 108 cc. of nitric oxide. Nitric acid sp. gr. 1.502 gives a nitrocellulose which yields 202.1 cc. of nitric oxide, and which is soluble in acetic ether and alcohol-ether solution. Only a mixture of nitric with sulphuric acid will furnish military gun-cotton. With such a mixture at 11° a cotton was obtained which was completely soluble in acetic ether, but completely insoluble in alcohol-ether, and which yielded 214 cc. of nitric oxide. If the formula be

$$C_{24}H_{29}(NO_2)_{11}O_{20},$$

theory requires 215.6 cc. An excess of sulphuric acid retards the rapidity of the reaction, while Nordhausen sulphuric acid proved no more serviceable than any other. The mononitrocellulose was obtained as a friable paste which was insoluble in both acetic ether and ether-alcohol solution.

Some years ago an article went about the press describing a novel kind of gunpowder which possessed great power, and was said to have been adopted by the Prussians. It was composed of sawdust and nitre in certain proportions, and was thought to be harmless in this condition. To render it explosive, enough sulphuric acid was added to make it cohere, and when dried it was ready for use. Cheapness, simplicity in manufacture and safety were claimed for this powder, and it was said to leave little residue when fired. It does not, however, seem to have come into use.

On the 28th of January, 1876, an explosion occurred on the premises of the Triumph Safety Powder Co., in Baltimore, Md. Fire Inspector Holloway held an examination, before which the inventor and stockholders swore to the nature and composition of the powder, and on the 31st he gravely reported that "the safety powder is a chemical compound made of the following ingredients: nitrate of soda or potash, sulphur, peat or charcoal, or hard coal with oily matter, vegetable, animal, or mineral, or tar, or any substitute thereof. Its process is to make a solution of the nitrate; mix it with highly dried peat and oleaginous matter and sulphur, and boil it under superheated steam at temperature of 250 F. during about one hour until the watery element is rarified. Then the compound becomes

thick, and the temperature is slowly reduced from 250° to 150° F., when the compound is finished to be dried."

"By the solution of sulphur and nitrate in contact with the oily matters a certain portion of nitro-glycerine or nitro-tar is produced in its latent and safe state, which is incorporated in the whole mass, and makes the powder inexplosive in the open air, and also doubles its dynamical power. At all the numerous tests to which it has been subjected those qualities have been fully demonstrated, and in none more satisfactorily than at the said fire."

Experiments have been made at Cherbourg with a new explosive invented by Eugene Turpin, called "Panclastite" or "Brise-tout." It is said to be composed of two liquids, each non-explosive when alone, but when mixed together, just as wine and water are mixed, a fulminating compound is produced which can be exploded either by ignition or percussion. The experiments made by the iron plate and the lead cylinder tests showed it to be much more powerful than dynamite, while by trial it was shown to be much less sensitive to a blow.—*Rivista Marittima*, **25**, 10, 143, October, 1882.

From the meagre description given we are unable to learn the composition of this explosive, but it appears to be of the same nature as those invented by Dr. Sprengel.—*Chem. Soc. Jour.* [2] **11**, 796. These are mixtures of a combustible and an oxidizing substance which can be kept separate during transport and mixed only when required for use. A mixture of nitro-benzine or of picric acid with nitric acid (sp. gr. 1.5) are types of the class. When fired by a detonating cap they explode with a violence which is only comparable with that of nitro-glycerine. The liquid state, the corrosive character of nitric acid and its ready solubility in water, are all serious objections to these explosives.

Prof. T. W. Tobin in lecturing on *Explosive and Dangerous Dusts* before the Fire Underwriters Association of the Northwest, experimentally illustrated the way in which the dust of flour and other mills gives rise to explosions, and cited data to show that these explosions are most likely to occur during a period of high temperature, high barometer and marked absence of humidity. Among other cases recorded were the explosion of starch in a candy factory in Minneapolis, of barley in the Ehret brewery, and of sawdust in the Pullman Car Works.—*Jour. Franklin Inst.* [3], **84**, 6, 412, December, 1882.

Through the courtesy of the Office of Naval Intelligence we have received a copy of a pamphlet entitled *The Doterel Explosion*,* by Thomas Rowan, C. E , E. & F. Spon, London, 1882. After criticising severely the reports of the various boards appointed to investigate the explosions on the Doterel and Triumph, and describing the internal arrangement of the ship and her stores by the aid of diagrams, he discusses the probability of the explosion being due to gas from the coal, and dismisses this as unlikely, since the ship was nearly out of coal; the bunkers were ventilated; no rise in temperature was noted in the bunkers where the temperature was taken every four hours; the bunker lids were probably off, as the order had been passed to prepare for coaling; too long a time had passed since coaling, as explosions usually occur within three days, and the longest time recorded is of an explosion which occurred thirteen days after coaling; and finally *no explosion took place abaft the magazine where the coal bunker was placed.*

In the fact that xerotine siccative was stowed in the mast-hole close to the fore magazine; that xerotine siccative contains benzoline; that benzoline is very volatile at ordinary temperatures (viz. 50° to 60° F.), yielding a vapor which readily diffuses with air, forming with it a most dangerous mixture, one volume of benzoline with 60 volumes of air being highly inflammable, and with 30 volumes highly explosive; and that on the day previous to the explosion *the magazine had been opened on two occasions,* allowing the inflammable mixture an opportunity to drift into the magazine, the author finds all the conditions necessary for an explosion. All that remained necessary was that the gas should be fired. The conditions here presented were such as Colonel Majendie found existed on the canal boat Tilbury, which exploded in Regent Park, October 2, 1874. On board the Tilbury, prior to the accident, were five tons of gunpowder and four barrels of benzoline in the hold. Communicating with the hold by means of a small ventilating hole was the after-cabin, and in the cabin a small open stove. Benzoline vapor from the barrels made its way into the cabin and was ignited, and an explosion of the vapor in the hold ensued, and the gunpowder exploded thirty seconds after. So in the Doterel there were two explosions.

At the Royal Powder Works at Spandau, Prussia, frequent ignition of the powder at a certain stage of the process led to an exami-

* *Vide* Proc. Nav. Inst. Vol. VIII, 313 and 459.

nation of the machinery, when it was found that where at certain parts, bronze pieces, which were soldered, were in constant contact with the moist powder, the solder was much corroded, and in part entirely destroyed, and that in the joints a substance had collected which, on being scraped out with a chisel, exploded with emission of sparks. It was suspected that the formation of this explosive material was in some way connected with the corrosion of the solder, and the subject was referred for investigation to Rudolph Weber, of the School of Technology at Berlin. The main results of his investigation are as follows:

The explosive properties of the substance indicated a probable nitro-compound of one of the solder metals (tin and lead), and as the lead salts are more stable and better understood than those of tin, it was resolved to investigate the latter, in hope of obtaining a similar explosive compound. Experiments on the action of moist potassium nitrate or pure tin led to no result, as no explosive body was formed. Stannous nitrate $Sn(NO_3)_2$, formed by the action of dilute nitric acid on tin, has long been known, but only in solution, since it is decomposed on evaporating. By adding freshly precipitated moist brown stannous oxide to cool nitric acid (sp. gr. 1.20) as long as solution occurred, and then cooling the solution to —20°, Weber obtained an abundance of crystals of the composition $Sn(NO_3)_2+20H_2O$. They resemble crystals of potassium chlorate. They cannot be kept, since they liquefy at ordinary temperatures. An insoluble *basic* salt was obtained by digesting an excess of moist stannous oxide in a solution of stannous nitrate, or by adding to a solution of stannous nitrate, by degrees, with constant stirring, a quantity of sodium carbonate insufficient for complete precipitation. Thus obtained, the basic salt, which has the composition $Sn_2H_2O_7$, is a snow-white crystalline powder, which is partially decomposed by water, and slowly oxidized by long exposure to the air or by heating to 100°. By rapid heating to a higher temperature, as well as by percussion and friction, it explodes violently, giving off a shower of sparks. This compound is also formed when a fine spray of nitric acid (sp. gr. 1.20) is thrown upon a surface of tin or solder. It is also formed when tin or solder is exposed to the action of a solution of copper nitrate, and thus formed, presents the properties already described.

In this, then, we have a probable cause of the explosions occurring in the powder works; but the explanation of the formation of the substance is wanting, as potassium nitrate was shown not to give an

explosive substance with tin. A thin layer of a mixture of sulphur and potassium nitrate was placed between sheets of tin and copper foil, and allowed to stand, being kept constantly moist. After a time the copper was found to have become coated with sulphide, while the tin was largely converted into the explosive basic nitrate. The conditions are obviously the same as those found in the powder machinery, where bronze and tin solder are constantly in contact with moist gunpowder. The chemical action is probably this: the sulphur of the powder forms with the copper of the bronze, copper sulphide; this is oxidized to sulphate, which reacts with the nitre of the powder, forming potassium sulphate and copper nitrate; the latter, as shown above, then forms with the tin of the solder the explosive basic nitrate, which, being insoluble, gradually collects in the joints and finally leads to an explosion.—*Am. Chem. Journal*, Notes, **4**, 4, 327, Oct., 1882; *Jour. für praktische Chemie* [2], **26**, 121.

The product of the Spanish Powder Mills for 1882 is fixed at 222,000 kilos, divided as follows: For the powder mills of Murcia, 60,000 kilos of prismatic powder, part with one and part with seven perforations, 30,000 kilos of 6 to 10 mm. powder, and 30,000 kilos of pebble powder. At the Granada Powder Mills, 12,000 kilos of prismatic powder and 90,000 kilos of reworked musket powder.—*Mitt. Artill. u. Genie-Wesens*, 1882, *Kleine Notz*, 203.

Extra Census Bulletin of the United States, entitled *Report on the Manufacture of Firearms and Ammunition*, fixes the value of the product of ammunition for 1880 at $1,929,966, the number of establishments in operation at five, and the capital invested at $834,000. This manufacture is described as being characterized by the use of methods which are distinctively American in their origin, and marked by great ingenuity, a wonderfully prolific output, and a quality surpassing anything approached by methods employed in foreign countries, or in any country prior to the past decade. Brass and copper shell cartridges did not come into use until some thirty years ago, when their importance in making gas-tight joints in breech-loading systems began to be recognized. The prominence which their manufacture has now attained in this country in supplying foreign nations with ammunition is due not only to the ingenuity which has developed the mechanical methods employed, but also to the purity and ductility of the American copper used in the manufacture.

Since cartridges have been found to deteriorate from the chemical action taking place between the salts of the gunpowder and the material of the shells, means have been sought to prevent this, and the shells are now coated, by an ingenious automatic machine, with an impermeable elastic varnish. The description given of this machine, as well as of the various processes employed in the cartridge manufacture, is quite interesting.

NAVAL INSTITUTE, ANNAPOLIS, MD.

JANUARY, 1883.

OCEAN LANES.

A LETTER FROM CAPT. JOHN CODMAN.

I have read with interest and care the "Discussion on Ocean Lanes" in Vol. VIII, No. 2, of your instructive magazine. My old friend, Capt. R. B. Forbes, who is interested in every good word and work pertaining to sailors, has made this subject a specialty for many years, and is justly accorded the first place among those who have contributed their essays. But I have looked in vain through his paragraphs, and those of the writers who follow him, for an explanation of the means of making the theory accord with the present conditions of ocean steam navigation. They all appear to reason from premises of the past.

When the matter was first agitated, among its earliest advocates was the late William Wheelwright, of Newburyport, whose enterprise was conspicuous in opening steam communication with South America, and navigating the first steamship through the Straits of Magellan. Without discussing the priority of the conception of steam lanes, it is sufficient to say that Mr. Wheelwright labored assiduously to impress the importance of the subject upon the attention of the British Admiralty and the London Board of Trade. He published a chart, a copy of which I have seen. Upon it was inscribed:

To the Right Honorable Chichester Fortescue, President of the Board of Trade, London:

This chart, showing an eastern and western route for steamers across the Atlantic, whereby collisions may be avoided and the fleet of fishing vessels on the banks of Newfoundland protected, is respectfully submitted to your consideration by Your obedient servant,

WILLIAM WHEELWRIGHT.

When this chart was projected the Cunard line had almost the monopoly of transatlantic steamship business. Accordingly, the lines of the lanes were distinctly and unmistakably drawn between

Boston and Queenstown. The projector, however, appears to have anticipated the further progress of steam navigation, for he appended this note: "These bands or zones are subject, of course, to such alterations as time and experience may suggest."

That time has long since arrived, and the changes have been so great that no alterations are practicable. Steamships are now running daily to and from ports, ranging on the American coast from the Gulf of St. Lawrence to the Gulf of Mexico, and to and from ports on the other side of the Atlantic from the north of Scotland to the Straits of Gibraltar. It is utterly impossible, therefore, to designate two distinct lanes in which these steamships coming and going from so many different points can by any possibility confine themselves. They must of necessity cross each other's tracks. The original plan of steamship lanes cannot therefore be carried out.

It is useless to deny that, with the increase of steamships and the acceleration of speed, the danger in crossing the Atlantic is on the increase. Fogs, and the liability to collision in fogs, are inevitable. No system of lights or signals can prevent accidents. There is a risk, but let us make that risk as small as possible. Unfortunately, as Americans, we have no voice in the matter, excepting as passengers, for our laws do not permit us to own and sail the ships. But the owners and commanders of these foreign steamships have a regard for their own safety, and may therefore be willing to listen to suggestions which have that end in view.

I know of no better way to attain at least a degree of security than to ask the agents of each and every one of the lines to obtain from their captains the outward- and homeward-bound tracks they are willing to follow on their passages, and, having obtained these data from them, for the Hydrographic Office to issue a chart upon which they shall be distinctly defined.

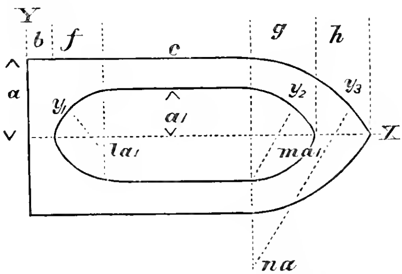
At the two ends, and for some distance from them, the chart will have the appearance of the crossing of telegraphic wires in Wall street. In fact there will be frequent meetings of the tracks. But this result will follow: not only steamships, but sailing vessels, all having copies of this chart, will be notified of the places of the greatest danger, and of the points from which it is most likely to come. They can accordingly take extra precautions and keep a particularly bright lookout.

I submit these views to the consideration of the Naval Institute, in the hope that they will elicit further discussion and possible amendment.

ORDNANCE NOTES.

LIEUTENANT C. A. STONE, U. S. N.

RADIUS OF GYRATION OF A RIFLED PROJECTILE.



Equations of Sections.

$$y_1 = \sqrt{l^2 a_1^2 - x^2} - (l-1)\,a_1$$
$$y'_2 = \sqrt{m^2 a_1^2 - x^2} - (m-1)\,a_1$$
$$y'_3 = \sqrt{n^2 a^2 - x^2} - (n-1)\,a.$$

Also, $$g + h = a\sqrt{2n-1} = Na,$$
$$g = a_1\sqrt{2m-1} = Ma_1$$
and $$f = a_1\sqrt{2l-1} = La_1.$$

The integral expression for K^2 will therefore be

$$K^2 = \frac{1}{2}\,\frac{a^4\int_0^b dx + \int_0^{La_1}(a^4 - y_1^4)dx + \int_0^c (a^4 - a_1^4)dx + \int_0^{Na} y_3^4\,dx - \int_0^{Ma_1} y_2^4\,dx}{a^2\int_0^b dx + \int_0^{La_1}(a^2 - y_1^2)dx + \int_0^c (a^2 - a_1^2)dx + \int_0^{Na} y_3^2\,dx - \int_0^{Ma_1} y_2^2\,dx}.$$

Let $$a^5\mathfrak{N} = \int_0^{Na} y_3^4\,dx, \quad a_1^5\mathfrak{M} = \int_0^{Ma_1} y_2^4\,dx, \quad a_1^5\mathfrak{L} = \int_0^{La_1} y_1^4\,dx$$

and $$a^3\mathfrak{n} = \int_0^{Na} y_3^2\,dx, \quad a_1^3\mathfrak{m} = \int_0^{Ma_1} y_2^2\,dx, \quad a_1^3\mathfrak{l} = \int_0^{La_1} y_1^2\,dx;$$

$$\text{then}\quad K^2=\frac{a^2}{2}\cdot\frac{\frac{1}{a}\left[b+La_1\right]-\frac{a_1^5}{a^5}\mathfrak{L}+\frac{c}{a}\left[1-\frac{a_1^4}{a^4}\right]+\mathfrak{N}-\frac{a_1^5}{a^5}\mathfrak{M}}{\frac{1}{a}\left[b+La_1\right]-\frac{a_1^3}{a^3}\mathfrak{l}+\frac{c}{a}\left[1-\frac{a_1^2}{a^2}\right]+\mathfrak{n}-\frac{a_1^3}{a^3}\mathfrak{m}}. \quad (1$$

$$a^5\mathfrak{N}=\int_0^{Na}y_3^4dx=Na\left[n^4a^4+(n-1)^4a^4+6(n-1)^2n^2a^4\right]$$
$$-\frac{N^3a^3}{3}\left[2n^2a^2+6(n-1)^2a^2\right]+\frac{N^5a^5}{5}$$
$$-4(n-1)a\left[\int_0^{Na}(n^2a^2-x^2)^{\frac{3}{2}}dx+a^2(n-1)^2\int_0^{Na}(n^2a^2-x^2)^{\frac{1}{2}}dx\right]. \quad (2)$$

$$\int_0^{Na}(n^2a^2-x^2)^{\frac{3}{2}}dx=n^4a^4\int_0^{\sin^{-1}\frac{N}{n}}\cos^4\theta\, d\theta$$
$$=n^4a^4\left[\frac{\cos^3\theta\sin\theta}{4}+\frac{3}{8}(\theta+\sin\theta.\cos\theta)\right]_0^{\sin^{-1}\frac{N}{n}}.$$

When $x=na\sin\theta$.

When $x=na$, $\theta=\sin^{-1}\dfrac{N}{n}=\cos^{-1}\dfrac{n-1}{n}$;

substituting these values, we have

$$\int_0^{Na}(n^2a^2-x^2)^{\frac{3}{2}}dx=n^4a^4\left[\frac{N(n-1)^3}{4n^4}+\frac{3}{8}\left(\sin^{-1}\frac{N}{n}+\frac{N(n-1)}{n^2}\right)\right]. (3)$$

In the same manner

$$\int_0^{Na}(n^2a^2-x^2)^{\frac{1}{2}}dx=n^2a^2\int_0^{\sin^{-1}\frac{N}{n}}\cos^2\theta\, d\theta=\frac{n^2a^2}{2}\left[\theta+\sin\theta.\cos\theta\right]_0^{\sin^{-1}\frac{N}{n}},$$

$$\text{whence}\quad\int_0^{Na}(n^2a^2-x^2)^{\frac{1}{2}}dx=\frac{n^2a^2}{2}\left[\sin^{-1}\frac{N}{n}+\frac{N(n-1)}{n^2}\right]. \quad (4)$$

Substituting the values (3) and (4) in (2), we have

$$\mathfrak{N}=N\left[n^4-2(n-1)^4+\frac{9}{2}n^2(n-1)^2\right]-\frac{N^3}{3}\left[2n^2+6(n-1)^2\right]+\frac{N^5}{5}$$
$$-(n-1)\left[2n^2(n-1)^2+\frac{3}{2}n^4\right]\sin^{-1}\frac{N}{n} \quad (5)$$

For $\mathfrak{M}$ and $\mathfrak{L}$, substitute M and L for N and m and l for n in (5).

$$a^3\mathfrak{n}=\int_0^{Na}y_3^2dx=a^3\left[n^2N+(n-1)^2N-\frac{N^3}{3}\right.$$
$$\left.-2\frac{n-1}{a^2}\int_0^{Na}(n^2a^2-x^2)^{\frac{1}{2}}dx\right],$$

$$\therefore\ \mathfrak{n}=N\left[n^2-\frac{N^2}{3}\right]-n^2(n-1)\sin^{-1}\frac{N}{n}. \quad (6)$$

For $\mathfrak{m}$ and $\mathfrak{l}$, substitute M and L for N and m and l for n in (6).
The value of K^2 from (1) can now be calculated.

The moment of inertia of a solid ogival head will evidently be

$$\frac{W}{g}K^2 = \frac{\pi}{2}\cdot\rho\int_0^{Na} y_3^4\, dx = \frac{\pi}{2}\cdot\rho\cdot\frac{d^5}{32}\mathfrak{N},$$

when $d = 2a =$ diameter of projectile.
If $n = 3$, $N = \sqrt{5}$ and $\mathfrak{N} = .9778$,

and $$\frac{W}{g}K^2 = \pi\rho d^5 [.0152] \qquad \text{(A)}$$

[*Sladen's Principles of Gunnery*, Page 15, Note].

The volume of the solid head will be

$$V = \pi\int_0^{Na} y_3^2\, dx = \pi\frac{d^3}{8}\mathfrak{n}.$$

If $n = 3$, $\mathfrak{n} = 1.2588$ and $V = \pi d^3 [.1573]$. (B)

[*Sladen's Principles of Gunnery*, Page 15, Note].

Taking the following as approximate measurements from a 700 lb. Butler shell,

$$\begin{array}{lrl} n = 3. & b = & 5.2'' \qquad a = \dfrac{11.92''}{2} = 5.96'' \\ m = 2. & f = e = & 1.4'' \\ l = 1. & c = & 10.3'' \\ & g = & 3.2'' \\ & h = & 9.9'' \\ \hline \text{whole length} & = & 30.0'' \end{array}$$

whence $L = 1$, $M = \sqrt{3}$ and $N = \sqrt{5}$;
we find

$$\begin{aligned} \mathfrak{N} &= .9778, \text{ as before.} \\ \mathfrak{M} &= .7833, \\ \mathfrak{L} &= .5333, \\ \mathfrak{n} &= 1.2588, \\ \mathfrak{m} &= 1.0073, \end{aligned}$$

and $\mathfrak{l} = .6667$.

From (1) $$K^2 = \frac{(5.96)^2}{2}\,\frac{3.7737}{3.9437},$$

whence $$K = 4.1224''.$$

In Ordnance Note No. 148, issued by the Bureau of Ordnance, U. S. Army, Feb. 8th, 1881, the radius of gyration for this shell was found by experiment to be

$$K = 4.1005358''.$$

No great degree of accuracy is claimed for the dimensions given above, as they were obtained by actual measurement of a small drawing of this shell in Major Butler's work on "Rifled Projectiles."

ON THE RATIO OF THE FORCES NECESSARY TO GIVE TRANSLATION AND ROTATION TO A RIFLED PROJECTILE.

For the sake of simplicity the projectile will be a solid circular cylinder of radius a and length l. The principles will be the same in the case of the rifled projectile of any form, and, by substituting the proper radius of gyration, the results may be applied to any projectile.

A circular cylinder is given a motion of translation in the direction of its axis by a force P, and a motion of rotation around its axis by a force p tangent to its middle cross section, and perpendicular to its axis.

Let $x =$ distance travelled by the cylinder in time t.

Let $\theta =$ angle of rotation in same time.

Let $M =$ mass of cylinder.

If the cylinder makes one rotation while passing over a distance equal to n calibres, we have

$$x = \frac{na}{\pi}\theta;$$

whence

$$\frac{d^2x}{dt^2} = \frac{na}{\pi}\frac{d^2\theta}{dt^2}. \tag{1}$$

If we have a body rotated about an axis by any couple each particle dm will have at any instant the same angular velocity $\frac{d\theta}{dt}$, and this angular velocity would be retained forever, if there were no resistance, without the action of any couple. The effect produced by the couple is therefore to increase the angular velocity of all the particles, and it is measured by this increase. In the above case consider a particle within the cylinder of mass dm, the action of the couple will give to this particle an angular acceleration $\frac{d^2\theta}{dt^2}$; if r is its perpendicular distance from the axis, $r\frac{d^2\theta}{dt^2}dm$ its linear momentum. Taking the sum of the moments of all these forces throughout the body, and equating it to the sum of the moments of the external forces, of which it is the measure, we have

$$pa = \frac{d^2\theta}{dt^2}\int r^2 dm,$$

since $\frac{d^2\theta}{dt^2}$ is the same for all the particles;

$$\therefore \frac{d^2\theta}{dt^2} = \frac{pa}{\int r^2\,dm} = \frac{\text{moment of the external forces}}{\text{moment of inertia}}. \qquad (2)$$

In this case the moment of inertia of the cylinder about its axis is

$$M\frac{a^2}{2},$$

$$\therefore \frac{d^2\theta}{dt^2} = \frac{2p}{Ma}.$$

By definition, $$\frac{d^2x}{dt^2} = \frac{P}{M}.$$

Therefore by (1) we have:

$$\frac{P}{M} = \frac{na}{\pi} \cdot \frac{2p}{Ma} = \frac{2np}{M\pi};$$

or $$\frac{P}{p} = \frac{2n}{\pi}. \qquad (3)$$

If $n=40$, $P=25p$, nearly.

This result is given in an article on "Rifling for Heavy Guns," by Captain J. P. Morgan, R. A., Assistant Superintendent Royal Gunpowder Factories, read before the Royal United Service Institution, May 19th, 1873.

Equation (3) gives the ratio of the forces necessary to produce translation and rotation in the case of a solid circular cylinder.

ON THE RATIO OF THE RANGES OF A PROJECTILE MEASURED ON THE HORIZONTAL AND ON AN INCLINED PLANE IN A NON-RESISTING MEDIUM.

The object of this article is to determine under what circumstances the projectile will pass over, and the circumstances under which it will fall short of the object aimed at, when that object is not in the horizontal plane with the point of projection; the same elevation being given above the inclined plane as would be given above the horizontal plane if the object were situated in it

In *Cooke's Naval Ordnance and Gunnery*, second edition, Vol. II, Chapter XI, we find the following values of R the range on the

horizontal plane and r the range on a plane whose inclination to the horizontal is β.

$$R = 2h \sin 2\alpha \tag{1}$$

and
$$r = \frac{4h \cos\alpha \sin(\alpha - \beta)}{\cos^2\beta}. \tag{2}$$

Since we wish to compare the ranges R and r when α in the value of R is the same as $\alpha - \beta$ in the value of r, we have

$$\frac{r}{R} = \frac{\cos(\alpha + \beta)}{\cos\alpha \cos^2\beta} = \sec\beta\,(1 - \tan\alpha \tan\beta). \tag{3}$$

Let $\frac{r}{R} = v$, $\tan\alpha = a$ and $\tan\beta = u$, then

$$v = \sqrt{1 + u^2}\,(1 - au). \tag{4}$$

Taking the first derivative of v with reference to u, we have

$$\frac{dv}{du} = \frac{u - a - 2au^2}{\sqrt{1 + u^2}};$$

equating this to zero to find the values of u which make the ratio v a maximum or a minimum, we find

$$u = \frac{1 \pm \sqrt{1 - 8a^2}}{4a}.$$

If $8a^2 < 1$ there will be a minimum value of v for $u = \frac{1 - \sqrt{1 - 8a^2}}{4a}$, and a maximum value for $u = \frac{1 + \sqrt{1 - 8a^2}}{4a}$.

If $8a^2 > 1$ there will be no maximum or minimum value of v.

If $8a^2 = 1$, we have $u = \frac{1}{4a} = \sqrt{\frac{1}{2}}$, whence $\beta = 35°\ 16'$ and $\alpha = 19°\ 28'\ 15''$ and $\alpha + \beta =$ elevation $= 54°\ 44'\ 15''$. The second derivative reduces to zero for $u = \frac{1}{4a}$, and as the third derivative does not reduce to zero for this value of u, there is neither a maximum nor minimum value of v, for $u = \frac{1}{4a}$.

From (3) we see that $\frac{r}{R} > 1$ when β is negative. When β is positive and α is less than $19°\ 28'\ 15''$ there will be two values of β greater than zero for which $\frac{r}{R}$ will equal unity; that is to say, there will be two inclinations of the plane passing through the object for which the elevation will be correct. One of these inclinations will be

given by a value of $\tan\beta$ between $\frac{1-\sqrt{1-8a^2}}{4a}$ and $\frac{1+\sqrt{1-8a^2}}{4a}$, and the second inclination by a value of $\tan\beta$ greater than $\frac{1+\sqrt{1-8a^2}}{4a}$ and less than $\frac{1}{a}$, the latter being the value that makes $\frac{r}{R}=0$.

If β is positive and α is greater than 19° 28′ 15″, $\frac{r}{R}$ will be less than unity, or the projectile will always fall short.

In the case of the trajectory in the air, since its equation is not known, we are compelled to determine in each case whether the projectile will pass over, or will fall short of the object aimed at on the given inclined plane.

PROFESSIONAL NOTES.

ON COMPASS CORRECTION IN IRON SHIPS.

By Staff-Commander E. W. Creak, R. N.

(*From the Journal of the Royal United Service Institution.*)

The observer, provided with a small magnetic needle—with special pivot—for horizontal vibrations, and a small dip-circle and needle for vertical vibrations, finds at a place on shore free from local attraction the time of ten vibrations of each needle. On reaching the ship, vibrations similar in every respect are made at the standard compass position. The ship is then swung and a complete table of deviations observed on thirty-two points. After this, horizontal and vertical vibrations must be again observed, with the ship's head in a widely different direction from that of the first set. The necessary calculations having been made from these observations, the coefficients of deviation will be obtained and the compass can be corrected for the place of observation.

If, however, it be desired to have the analysis as complete as in the following table, for the purpose of computing probable changes in the deviation or applying a Flinders bar as a corrector, the ship must be swung again near the magnetic equator, or still better, in south dip.

The magnetic forces in an iron, and also in an iron armor-plated ship, proceed partly from sub-permanent magnetism in hard iron, and partly from transient induction in soft iron. In the table, P, Q, R represent the forces produced by sub-permanent magnetism in hard iron acting in three directions—fore and aft, athwartships, and vertically. Also a and e represent the forces produced by horizontal induction in horizontal soft iron fore and aft, and athwartships; and c, f, and k, those caused by induction in vertical soft iron acting fore and aft, athwartships, and vertically.

Coefficient λ shows how much the mean directive force acting on the needle is reduced, *i. e.* if the earth's force cause the compass on shore to point to the north with a force $=$ 1.0, on board ship that force may be reduced to 0.85 or less, thus giving the other disturbing forces more power to produce deviation. A knowledge of this coefficient is necessary to the exact correction of the heeling error.

Table of the Magnetic Elements at the Standard Compasses of four different classes of Her Majesty's Ships before Correction.

Ship's name	Nelson. Iron. Armor plated.	Raleigh. Iron cased with wood.	Comus. Iron and steel cased with wood.	Albatross. Composite.
Positions of swinging	Devonport. Simon's Bay.	Spithead. Simon's Bay,	Sheerness. Simon's Bay.	Sheerness. Rio de Janeiro.
Coefficients of deviation.				
Semicircular B	+16° 36′	+11° 46′	+17° 30′	+16° 33′
Semicircular C	− 4 7	+15 15	+ 2 0	+ 6 17
Parts of B—				
From hard iron P	+19 46	+12 45	+10 33	+12 18
From soft iron *c*	− 3 10	− 0 59	+ 6 57	+ 4 15
Parts of C—				
From hard iron Q	− 4 7	+15 15	+ 2 0	+ 6 17
from soft iron *f*	0 0	0 0	0 0	0 0
Quadrantal D	+ 4 0	+ 6 33	+ 6 9	+ 3 59
Parts of D from soft iron ± *a*	− 3 52	− 2 29	+ 1 0	+ 0 34
Parts of D from soft iron − *e*	+ 7 52	+ 9 2	+ 5 9	+ 3 25
Mean horizontal force on board to north, λ.	.830	.833	.932	.951
Heeling error for 1° of heel of ship	+ 0° 31′	+ 0° 33′	+ 0° 22′	− 0° 10′
Parts of heeling error				
From vertical induction in horizontal soft iron of the form −*e*	+ 0 39	+ 0 47	+ 0 26	+ 0 18
From hard iron R, combined with soft iron *k*	− 0 8	− 0 14	− 0 4	− 0 28

Note.—The sign — before *a* and *e* denotes that the form of iron which they represent is continuous in its relation to the compass—such as iron beams, decks, and keel. The sign + that the iron is divided, as in the case of the soft iron correctors.

Of these elements, P can be corrected by permanent magnets placed in the fore and aft direction, Q by magnets athwartships, R by a vertical magnet, taking care that the centre of each magnet lies in a vertical plane passing through the centre of the compass. Also —*e* by masses of soft iron on the starboard and port sides of the compass, and *c*, *f*, and *k* by a vertical soft iron bar with the upper end nearly on a level with the compass-card. *a* is masked by the invariable excess of —*e*, and requires no correction. λ is much improved by correcting —*e*.

When the standard compass is necessarily placed out of the midship fore and aft line, or there are turrets so placed, two additional coefficients are obtained from the deviation table, A and E. Thus the magnetic forces which give rise to a true A and E are produced by horizontal induction in soft iron unsymmetrically placed. A can be corrected by adjusting the needles on the card, according as its value is + or —; but as it is a constant error on every point

of the compass, and each compass in a ship would require special cards if the needles be moved, it seems better to leave it uncorrected. E can be corrected by moving the soft iron masses on each side of the compass into an oblique direction, according to the relative values of D and E.

Having learnt from the table the values of the several components of the total deviation at the standard compasses of four ships which require correction, the two most recently proposed systems of correctors devised by Sir W. Thomson and Lieutenant Peichl, of the Austro-Hungarian Navy, may now be considered as to their suitability for this purpose.

Sir W. Thomson's System.

Partly with a view to making the correction as exact as possible, Sir W. Thomson has invented a compass-card the needles of which are much shorter and of considerably less magnetic power than those hitherto in general use. By this means any induction caused by long powerful needles in the soft iron correctors is obviated.

For the correction of $-e$, a large portion of the heeling error from vertical induction in transverse iron, and part of λ, hollow or solid soft iron globes are employed of varying diameter according to the value of D. This correction remains perfect in all latitudes. Globes have been adopted in preference to other forms as being more symmetrical in action as correctors, and having the further recommendation, that by a simple formula the amount of λ corrected by them may be calculated.

P and Q are corrected by magnetized steel bars, placed in holes bored in the binnacle fore and aft and athwartships. The greater parts of P and Q are corrected by bars 9 inches long and .4 inch in diameter, and the small remaining parts by bars 9 inches long and .2 inch in diameter. The latter bars when first placed have a margin of holes above and below, so that they may be readily adjusted on small errors appearing in the compass.

c and k are corrected by a Flinders bar, or bar of soft iron, 3 inches in diameter and of varying length, placed before or abaft the binnacle. R by one or more vertical magnets in a brass can, placed vertically underneath the centre of the compass, which may be moved upwards or downwards by a brass chain.*

Lieutenant Peichl's System.

Comparing this system with that of Sir W. Thomson, it might at first sight be inferred that they totally differed in principle as well as in form of application, so unlike is one to the other. It is, however, only in the retention of the form of compass hitherto accepted, and in placing the soft iron correctors so near the compass needles as to cause induction in the correctors, that the difference in principle exists. Lieutenant Peichl calls his system a "Universal Corrector."

In this system the gimbal-rings are much larger than in the ordinary compass. From the inner ring a base-plate is suspended by four india-rubber bands. In

* For the excellent plates showing Sir William Thomson's compass and correctors with full letter-press descriptions, see vol. xxi, 1879, and vol. xxiv, 1881, Journal Royal U. S. Institution.

the centre of this base-plate the compass is fixed, and to the under side of it are screwed metal bearers, carrying fore and aft and athwartships adjustable magnets, intended to correct small changes in the deviation as they appear. From the centre of these bearers there hangs a horizontal metal plate, which can be turned in azimuth and carries four small magnets, arranged like the needles on the Admiralty standard compass-card. If this metal plate be turned in azimuth so as to bring the four parallel magnets upon it into an angle with the keel which can be computed by the relation of coefficients B and C, P, Q, and *c* may be corrected for one geographical position.

Inside the inner gimbal-ring are two metal disks, placed one above the other, each carrying thirty-two soft iron bars. The inner ends of these vary from 1 inch to 1½ inches in distance from the ends of the compass needles and form an ellipse; the outer ends form a circle.

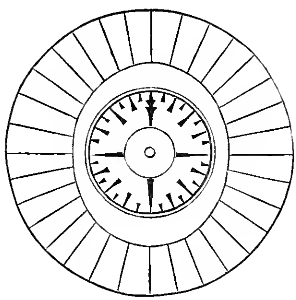


FIG. 1.

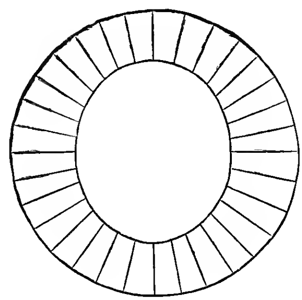


FIG. 2.

Fig. 1 shows the compass inside the lower disk and bars, Fig. 2 the upper disk and bars removed for illustration.

In Fig. 1 the bars improve λ and correct $-e$. If the disk in Fig. 2 be placed on that in Fig. 1, the action of the bars on the compass will be as follows:—When the major axes of the two ellipses are at right angles one to the other λ is improved 50 to 80 per cent. If both major axes be in the fore and aft line, λ is improved in a less degree, but $-e$ is corrected.

R and *k* are corrected by an adjustable vertical magnet in the pillar on which the compass urn is fixed.

No Flinders bar is used.

The magnets used in correcting P, Q, and *c* are unusually small, being bar-magnets of only 1 inch to 3 inches in length.

Remarks on the two Systems of Correctors.

For ships of the Royal Navy—and it may be also said of all ships—the method of placing the correcting magnets in the binnacle is decidedly preferable to securing them on the deck, and for adjustable magnets Sir W. Thomson's arrangement of holes in the binnacle is simple and can be made amply secure. Lieutenant Peichl's dual system of applying the correcting magnets seems to

be a departure from that simplicity which is so desirable, although it is reported to have been well received in the Austro-Hungarian Navy.

Next, as to soft iron correctors. When applied it is an advantage that the correction of the quadrantal deviation should be perfect in all latitudes. In this Sir W. Thomson has fully succeeded. Lieutenant Peichl has rejected this principle, and gives the soft iron the additional work of largely increasing the directive force on the needle. The increase of force thus gained entails the necessity of altering the correctors on change of latitude, introduces a small octantal error, and, unless the gimballing be perfect, a heeling error. There are, however, positions between decks in an armor-plated ship where the directive force is low, and where this arrangement might be adopted for steering compasses with advantage.

Lastly, the Flinders bar. Although for steering compasses, especially those placed near the ends of vertical iron, this bar would be of great service, yet there are certain objections to placing it near a standard compass:

1. A computation of the values of c, which the bar is principally intended to correct, for a large number of vessels of every class in the Royal Navy, shows that its value is generally small, and may therefore be conveniently corrected by the adjustable magnets when re-correcting P. k may be corrected by the adjustable vertical magnet when re-correcting R.

2. A vertical bar which is generally behind time in taking up the induced magnetism, due to the ship's new geographical position, might by the shock of firing heavy guns take it up suddenly, and a consequent sudden change in the deviation be caused.

3. As placed in Sir W. Thomson's binnacle, the lower end of the bar comes very near the ends of the fore and aft correcting magnets, and there is reason to believe that a small *permanent* induction may be caused by them in the bar which is intended to be magnetized by transient induction only.

Instruments for Correcting a Compass without bearing of Sun, Star, or Terrestrial Object.

The idea of an instrument by means of which a compass may be corrected or error discovered in a corrected compass during fog, or when no bearings of the sun or distant object can be obtained, can hardly fail to be inviting to the careful navigator, who knows how necessary constant observations of the deviation are to safe navigation. It is now proposed to inquire how far two recent forms of this instrument answer their purpose.

Sir William Thomson's Deflector.

It is a well known principle that when the directive force acting on the compass is equal for every direction of a ship's head there is no deviation. The directive force on different courses may be measured either by noting the angle of deflection produced by a magnet of a given magnetic power at a constant distance from the compass, or, if an invariable angle of deflection be adopted, by a magnet, the magnetic power of which can be varied at the will of the observer.

The latter method is adopted in this deflector, and the constant angle is 90°.

The deflector consists of a sole-plate supporting brass frames, to which two pairs of small steel bar-magnets are attached. These magnets are adjustable by means of a brass screw shaft. When less magnetic force is required to produce the 90° of deflection, the north poles of the magnets are made to approach the south poles, and when these are drawn apart the magnetic force is increased. A scale of distance is placed between the north and south poles.

To correct a compass.—Bring the ship's head to the north (if under way steer her by an auxiliary compass), place the deflector on the glass top of the compass-bowl and deflect the compass 90°, with the pointer over the E. b. N. point. Note the scale reading. Now bring the ship's head to due south by the compass and repeat the foregoing observations. If the scale readings for the two opposite courses differ, set the deflector to the mean value of them and bring the ship's head either to north or south. The angle of deflection will no longer be 90°, but must be made so by adjusting the fore and aft magnets.

By the same method find the mean scale reading for the east and west points of the compass, and correct the compass by adjusting the athwartship magnets.

Finally, if the deflector reading for the east and west points differs from that for the north and south points, the soft iron globes must be adjusted according to given rules. If the readings are alike, the compass is correct on all points.

If the value of the scale divisions be known, the deviation can be found by observations similar to those described above.

Lieutenant Peichl's "Control Compass."

This instrument is an application of the magnetic dip-needle, principally to the purpose of detecting any small errors which may exist in a corrected compass, but also may be used for observing large deviations.

Theoretically it is based on the well known action of the dip-needle on land—that if its circle be placed in the magnetic meridian the needle shows the least dip. If the circle be moved in azimuth alternately to the east and the west of the magnetic meridian, so as to cause the needle to show increased and equal values of dip, the circle will have passed through equal azimuths, the mean of which is magnetic north.

Now, if instead of turning the circle in azimuth it is clamped after being placed in the magnetic meridian, and the ship be turned in azimuth, the whole of the magnetic forces of the ship will remain constant, in respect to the dip-needle, which will now be affected only as before described for a needle on land, with the exception of a small error produced by —*e* (see table). This last source of error being constant, is determined once for all in harbor, and can always be allowed for in setting the control compass.

The following is a brief description of the "Control Compass": The foot-plate, graduated to degrees, is placed within an urn on a wooden pillar, similar to the standard compass of the Royal Navy. The dip-needles, of which there are a pair pinned together about 0.3 inch apart, carry a small mirror near the axles, which have knife edges and rest in grooves formed in the agate planes.

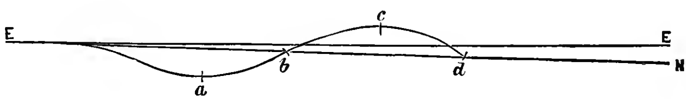
These agate planes are mounted on a gimballed plate, connected with the graduated plate, so as to be used at sea. Two metal arms project from the gimballed plate, one of which carries a graduated ivory scale, the eye-pieces, and two small rotating magnets for bringing the dip-needles into an arbitrary dip—the other arm a vane and thread.

To observe.—Turn the needle casing in azimuth until the dip-needles are in the computed magnetic meridian, look through eye-piece on the mirror, and move the rotating magnets so as to bring the reflected zero of the scale to coincide with a line on the mirror. This will show that the needles are indicating the smallest value of the dip, and the movable circle must be clamped.

Fig. 3 shows an example of the ship's course during the observations, ship starting from a supposed easterly course.

E, E is the course lately steered, E, N the new and correct course by compass to make an easterly course.

FIG. 3.



Starting from E the ship's head is turned to starboard until the maximum dip (marked by three dots on the scale) is observed at *a*. The ship is now turned to port until *b* is reached, when the minimum dip is observed. Continue the turning to port until the maximum dip is observed at *c*. Bring the ship s head back to the minimum dip at *d*, having noted the direction of the ship's heaa by standard compass at the instant of the ship arriving at *a*, *b*, *c*, *d*.

Then if the arc read on the compass in turning from *a* to *c* does not exceed 90°, and the mean of the compass courses observed at those points does not differ more than 5° from the given magnetic course, steer on the mean of these compass courses.

If the above limits of 90° and 5° are exceeded there is evidence of large error, and the compass correctors must be adjusted according to given rules,* observations about the two cardinal points adjacent to the compass course being sufficient.

Remarks on the Deflector and Control Compass.

Of these two instruments the deflector is intended for use both at sea and in harbor, but only with Sir W. Thomson's compass. There can be no doubt that in skilful hands this deflector fully answers its purpose, and has already been successfully used at sea ; but reasons will hereafter be given for thinking that its place is rather as a valuable aid to the practised compass adjuster than the navigator.

The control compass is more especially intended for use at sea, and with any form of compass. The idea of the control compass is both novel and very

*See "Instructions for the use of Lieut. Peichl's Patent Controlling Compass," &c. Trieste, 1880.

ingenious, but there are certain practical objections to its use which require notice.

In the first place, the instrument should with its pillar be placed as satisfactorily as regards surrounding iron as the standard compass, a condition difficult of fulfilment. Then the preliminary harbor observations for corrections of $-e$ must occupy a long time, and require especial advantages for turning the ship in azimuth.

The necessity for different needles in north and south dip is a complication, and the possibility of unsteadiness of the needle in a seaway has to be considered. Like the "universal corrector," the "control compass" has been reported upon favorably in the Austro-Hungarian Navy.

Instruments for Ascertaining and Correcting the Heeling Error.

Among other appliances for use in connection with Sir W. Thomson's compass is an instrument by which heeling error may be detected with the ship upright, and suitable correction made, when knowing, or being able to estimate λ (see table). By an easy observation on shore (where there is no local disturbance) and a similar one on board, the vertical corrector magnet may readily be adjusted to the required position. Instruments constructed on this principle would be useful with any form of compass.

Concluding Remarks.

From a study of the methods of compass correction just described in conjunction with the numerical results obtained before and after correction in a large number of different classes of vessels, some conclusions have been drawn which will be now offered for the consideration of those who wish to adopt real improvements, whilst rejecting those of a partial nature often made at the expense of some well-established principle.

Amongst other principles is one all-important, that no system of correctors has yet been devised which should encourage any relaxation in the great care required in providing as good a position as possible, with regard to surrounding iron, for every ship's standard compass.

Simplicity and strength should govern the choice of correctors. Those that are necessary may be shortly described as permanent magnets, either fixed or adjustable, fitted in the binnacle for correcting the semicircular deviation and heeling error, safeguards against their disturbance except by authorized officers being provided. For the quadrantal deviation, masses of soft iron, which may be either globes, cylinders with spherical ends, or thin laminæ. If this correction by soft iron is to be perfect in all latitudes, the compass-card must be constructed for that purpose. In attaining this perfection, however, involving perhaps only 2° to 3° deviation, care must be taken that essentials are not sacrificed, such as sufficient directive force, steadiness at sea, and suitable size.

When a standard compass is properly placed there is little or no need for frequently moving the correcting magnets. The Admiralty Instructions provide that every ship shall be swung on any considerable change of latitude, and

once a year wherever she may be. Such times are here suggested as convenient for re-correcting the compass, if required, the swinging taking place after the correction to ascertain the amount of residual deviation.

No system of correctors enables the navigator to dispense with the habit of daily observations, and record of the deviation. Further, if the ship be occasionally swung at sea, sufficient knowledge of the deviation in different latitudes may be obtained to permit of courses being steered in reasonable safety when sights cannot be taken for several consecutive days. Thus, special instruments for observing the deviation without sights at sea will scarcely be wanted by the careful and intelligent observer.

When a system of observation and subsequent analysis as shown in the previous table is carried out, not only are data provided for the accurate correction of compasses, but also the power of estimating with considerable accuracy certain useful data when they cannot be obtained by observation. With the assistance of these estimated values a ship's compasses may be nearly corrected without moving her from the wooden jetties of the Royal dockyards.

In concluding this paper, it may be remarked that with the increasing speed of modern ships, instruments of precision for navigating them are more than ever necessary. Navigators and all who value life and property at sea can hardly fail to be grateful to those who give their time and talents with a view to making the compass more than heretofore an instrument of precision in iron ships.

THE BELLEVILLE INEXPLOSIVE BOILER.

Notices have recently appeared in several European papers in relation to the trials made in the French Navy of this boiler aboard the Voltigeur, and its introduction into the Milan. It has been in actual use aboard the former for two years, and its successful operation there has led to the further test of using it aboard the Milan, whose engines are to be of 3800 H. P.

The commanding officer of the Voltigeur has made a report to the Minister of Marine, of which the following is the summation :

" From what precedes, it can almost be said that the boilers of the Voltigeur are now in as good condition as at the beginning of the cruise, and that they can be expected to remain in this state for a long time to come.

" I am then led to state, after a cruise of two years, that the boilers of the Voltigeur have fulfilled all the conditions of the test imposed upon them by the examining board in—

" Security and strength.

" Rapidity of forming steam.

" Absolute absence of foaming and of foreign bodies in the cylinders.

" Facility in obtaining and changing the pressure.

" Economy of fuel."

REVIEWS.

No publication will be noticed under this head, unless a copy, to be placed in the Institute Library, is sent to the Corresponding Secretary at Annapolis, Md.

MAGAZINE RIFLES. By Lieutenant-Colonel G. V. Fosbery, V. C. Journal of the Royal United Service Institution, No. CXVI.

In his excellent lecture on magazine rifles last May, Colonel Fosbery states some well-known truths, which in the present condition of our small-arm armament and of our small-arm men, it may be well for us of the Navy to seriously consider. And, indeed, in view of the fact that we constantly hear able officers expressing themselves as doubtful of the expediency of putting magazine rifles in the hands of seamen, and as certain that "Jack" can never arrive at that condition of responsibility in which he could be trusted to manipulate a double-acting revolver, it would seem absolutely necessary for the service to decide upon the acceptance or rejection of some of Colonel Fosbery's axioms and to govern itself accordingly.

If the small-arm fighting machine consists of a human and a mechanical part, and if the mechanical part "should be the quickest and best attainable; and the other part, *i. e.* the man, should then be levelled up to it by careful instruction," it is evident that the Navy should have magazine rifles and double-acting revolvers, and that the men should possess that degree of intelligence necessary for using them effectively; but if this degree of intelligence is unattainable, either through lack of opportunities for suitable instruction or through incompetency of the officers or stupidity of the men, then the arms should be such as could be understood, single-loaders for example, or bows and arrows, or spontoons, or brickbats; in which case it is evident that our fighting machines, being so very inferior in both human and mechanical parts, should be carefully kept from coming in contact with those of other nations.

If it be true that the end and aim of all tactics and of every manœuvre are but to place the man in the most favorable position for using his weapon with effect, then our practice and tactics should point in that direction; aboard ship and within certain limits they do this. As nearly as may be, the men are trained to get in position for using their small-arms in repelling boarders, in boarding, and in pouring in small-arm fire upon an enemy's decks or through his ports. But ashore, the end and aim of our tactics seem to be to get the men in two straight lines and make them look well. This has been attempted for a great many years, without success in a single instance; every renewed attempt strengthens the conviction that the two shoulder-to-shoulder lines are not straight and that the men do not look well. This kind of amusement

may be indulged in indefinitely if we accept the dogma of a high authority—that no officer now living will ever hear the report of a gun hostile to the United States—and consequently do not consider it the duty of the Navy to, in any way, provide for an impossible contingency; but if, on the other hand, we consider it our duty to get ourselves in condition to meet the homo-mechanico fighting machines of other nations ashore, it behooves us to change the end and aim of our tactics and make them conform to the conditions required ashore, conditions so plainly given by Colonel Fosbery: "For as he will never again stand shoulder to shoulder with his comrades and fire volleys at similar lines at 400 paces, so he will seldom find a skirmisher waiting to receive his fire at 300, but he will continually be called on to take snap shots at running, bounding, dodging men at every conceivable distance within the range of his rifle, to hit heads half shown above shelter, trenches, bushes or tufts of grass, or pay in his proper person the penalty of his bad shooting: and he will have, moreover, while lying under cover himself, to learn to judge the distance of his enemy."

If we accept these conditions as those that must obtain in shore fighting, it is evident that we must either be prepared to meet them or must abandon the idea of putting our men ashore to meet, even in small numbers, civilized or only semi-barbarous enemies. In this connection it is well to consider, in passing, why and how we might wish to throw an efficient naval force on shore. In case of a foreign war brought on by Isthmian Canal complications, or by the fact that, shirk them as we may, the United States have, as a member of the family of nations, certain national duties to perform, it is generally conceded that there would be no attempt to defend our coasts in their entirety, but only to hold, as best we might, the richer seaports and the more important stragetic points. A strong enemy would throw forces ashore at the undefended points, not perhaps with the idea of making any material advance into a country with so strong a fighting population as ours, but for the purpose of harrying our coasts, destroying supplies, &c., as was done by the British in 1812–14. Under our present policy the Navy would never be strong enough to oppose such a landing; but if it were able to throw on shore an efficient shore-fighting force, however small it might be in comparison with that of the enemy, it could give a good account of itself in hanging on the enemy's flank, harassing and possibly checking him until a sufficient shore force proper could be brought up to effectually dispose of him altogether.

Just as the cavalry of the shore must in the future be more and more prepared to fight dismounted, so must "the cavalry of the sea" be prepared to fight disembarked.

The necessity for the utmost rapidity of fire for the critical moments afloat and ashore, that grow shorter and more critical as the precision of arms increases, has been so often shown that it would seem to be a work of supererogation to more than refer to it; still in his lecture Colonel Fosbery, and in the following discussion Admiral Boys, both take occasion to accentuate this need; and so, following in the lead of these eminent officers, the writer would submit that for boarding and repelling boarders and torpedo boats afloat, for charging

and repelling charges ashore, magazine small arms, in so far as small arms are useful at all, are the—*without which nothing*.

Colonel Fosbery speaks of the rapidity of fire of the Martini-Henry—a fairly good single-loader, but inferior in breech mechanism to several American guns—and in this connection it may be well to observe that the supply of ammunition is not increased by the use of magazine arms. The opponents of magazine arms are fond of declaring that since it is difficult to supply single-loaders with ammunition, it will be impossible to fulfil the insatiate demands of repeaters. The repeaters, however, give a greater rapidity of fire only when using the charged magazines, and, as a matter of fact, a man can fire a given number of cartridges—great enough to require him to recharge his magazine three times—in less time from a single-loader than from the magazine of a repeater. There seems to be a theory that anything like fire discipline is impossible and that every man in action will proceed to expend his ammunition as rapidly as possible without harming any one; that consequently the slowest firing arm is the best, because that gun best conserves ammunition, and the people who have ammunition at the end of a battle necessarily win the fight; and that men are so constituted that the time used in action is better expended in loading than in aiming and firing. It is evident that the question of ammunition supply is a most important one, be the arms single-loaders or repeaters; but to say that all the time possible should not be devoted to aiming and firing rather than to loading is absurd.

There are a few points in connection with the new 40 cal. Martini-Enfield that Colonel Fosbery speaks of, that it would be well for us of the Navy to consider, especially at a time when questions of a new musket for the service are being discussed.

It is now generally admitted that .45 is too large a calibre; because, in order to get range and accuracy with that diameter of bullet, too great weights of powder and lead are needed and too great recoil ensues. Our own cartridge of 70 grains of powder and 405 of lead gives a sharp recoil, and the 80 of powder and 485 grains of the Boxer wrapped cartridge give rather a heavier recoil than the average man can endure for a long action. At the time .45 was adopted as the army calibre, there was considerable argument by members of the board in favor of .40. One of the points against it was that a bullet of that calibre was too small to stop a man or empty a saddle even when it found its billet in the trunk. Admiral Selwyn makes this point in another way in his remarks on Colonel Fosbery's lecture, but the Admiral seems to labor under the misapprehension that the smaller calibre necessarily means a lighter bullet, as is indeed the case in the new Martini-Enfield cartridge as compared to that fearfully and wonderfully made affair known as the Boxer cartridge. Now it is apparent that if the bullet of smaller calibre be of the same weight, and if it be not so long that the loss of velocity due to skin friction is greater than the gain due to decrease of diameter, the powder charge being the same, the smaller calibre missile will fly farther, go straighter and hit harder than the one of greater diameter. As regards the size of hole that it is necessary to bore through a man to drop him in his tracks when a vital point is not struck, that

depends very much on the kind of man. A 405 grain .40 calibre bullet received in the trunk will stop any civilized man who has nerves; a couple of 500 grain .45 calibre bullets received in the same place will not always stop a semi-vegetable savage.

In the light of present development and while small-arm powder is in its present crude and unworked condition, it seems to the writer that the military cartridge of the immediate future should consist of a 40 calibre canalured bullet of about 400 grains, in front of about 80 grains of powder contained in a non-corrosive, drawn, metal shell, trumpeted as much as conditions of feed in magazine and machine guns will allow in order to give as little movement as possible to extract a miss-fire. Such a cartridge will be long as compared with the present service ammunition, but its weight would be only five grains more and its bulk only that due to increase in powder charge from 70 to 80 grains.

In connection with the general question of ballistic power of shoulder-pieces it would be well for us of the Navy to consider that of length of barrel. The Navy uses 28″ barrels because arms made up with them are more convenient for stowage under boat-thwarts and for use in contracted spaces generally, and are lighter. But with the service ammunition we lose nearly 100 feet of initial velocity and corresponding range and accuracy in comparison with what we would have with the 32″ barrel of the infantry arm, to say nothing of the loss of accuracy due to shorter distance between sights. It has sometimes been a cause of complaint that the Navy Hotchkiss was less accurate than the marines' Springfield. As reasonably might one complain because three is less than four. But is not this sacrifice of power to handiness too great? Rather than use barrels shorter than the generally adopted infantry length of 32″ the writer would urge following the example of the Argentines, and increasing it to 34″; even with this length, and a breech mechanism less awkward than the Springfield, a detachable magazine 40 calibre arm could be made of the same weight and not more than 1″ longer than the present U. S. Infantry gun. In these days of high powered arms large and small, the length of bore is one of the most important factors.

The new Enfield-Martini has, Colonel Fosbery tells us, an increase in the number of grooves and in the twist of rifling, both steps in advance. The quicker twist holds the bullet and allows the powder gases to better do their work, and gives the spin necessary for accuracy at long ranges, while the greater number of driving shoulders of the rifling prevents the bullet from stripping. The three-groove 22″ twist Springfield rifling answers the purpose for the present service ammunition, and is an excellent slow rifling—just as the Harper's Ferry flint-locks are excellent flint-locks.

Colonel Fosbery gives very succinctly his reasons for preferring a magazine near the centre of gravity of the piece, carrying the cartridges laterally, to a tubular one in either tip or butt stock—reasons that a couple of years ago caused the writer to favor the general principles of the Lee magazine—but he omits what would seem to be an important one, viz. that since, in the lateral holding magazine, the cartridges have only to move through distances due to

diameters instead of those due to lengths, the work is less and the moving device less powerful and more compact; again, the point made by Admiral Selwyn in the discussion, that the weight of a side-borne magazine would detract from verticality, is extremely well taken, apart from the fact that a magazine so placed causes a side-blow on recoil— a not unimportant feature when the recoil is to be close up to the man's limit of endurance. Evidently the ideal position of the magazine for distribution of weight is such that its centre of gravity is in that of the piece and does not change as it is filled or exhausted; but since this cannot be done without interfering with the line of sight, cutting away too much of the receiver, or for some other practical reason, the next best location is that in which its centre of gravity shall lie in the central vertical longitudinal plane of the piece, as in Lee and Spencer-Lee guns, and shall not change back and forth as the magazine is filled or emptied. In this respect these systems are superior to the Ward Burton, Fosbery or McEvoy, and to such quick-loading devices as the Metcalfe, called Kruka on the other side of the water. Colonel Fosbery is positive that no magazine should contain less than ten shots. But, of course, this is entirely a matter of opinion upon the duration of a critical moment, since at present no one holds that magazine fire for rapidity can be used for the whole action. Many military authorities think that five or six rounds will decide the failure or success of a charge.

It is more important that an attached magazine have great stowage capacity than a detachable one, since the former could not be recharged in the making or repelling of an assault: while the latter system contemplates the use of several magazines, any one of which could be put in play upon the gun, in less time than it would take to place a single charge in a single-loader, and thus renew the magazine fire in the heat of the critical moment. Taking into consideration the handiness, the protection of the magazine by the trigger-guard and the ease of manipulation, the Lee would seem to be very nearly right in size for a detachable magazine.

The advocates of the detachable magazine claim that it is superior to the fixed one in giving a greater number of rounds for magazine fire without lumbering up the piece with mechanism and weight of charged magazines, when it is in use as a single-loader; that it obviates the necessity of cut-offs, that great source of vexation and complication; that it gives the officer a better control over the fire of his men, since a glance tells him whether or not a man is in condition to deliver magazine fire; and that no injury to it can disable the piece as a single-loader.

On the other hand, those who favor the fixed magazine claim that it cannot be lost; is always in place upon the arm; that a cut-off is much more easily worked than its opponents admit; that fire discipline is just as easily maintained with the one system as the other; and that a sufficiently great number of rounds for critical moments can be constantly carried in it without materially increasing the weight or spoiling the balance of the piece.

The writer would favor:

1st. A spring-feeding, lateral-holding, detachable magazine like the Lee.

2d. A spring-feeding, quick-recharging, lateral-holding fixed magazine like the Russell.

3d. A positive-feeding, lateral-holding, revolving-acting, fixed magazine like the Cook, or the Green spoken of by Colonel Fosbery.

4th. A spring-feeding, separate end-on holding, fixed, butt-stock magazine like the Chaffee-Reece.

5th. A spring-feeding, end-on column holding, fixed, butt-stock magazine like the Hotchkiss or the Elliot.

The last has two tubes in the butt-stock, so that the stowage capacity is double that usual in magazines of this location. To be sure, the Evans screw magazine in the butt, which Admiral Selwyn mistakes for the Hotchkiss, gives still greater capacity, and, moreover, keeps the cartridges from impinging on each other, advantages more than offset by the fact that it requires just as much time to charge as it does to empty the magazine. At the present stage of improvement in small-arm magazines, it is hardly worth while to consider the under barrel tubular affairs.

The pendulum muzzle sight on the new Martini-Enfield is the application of an old idea for long range sighting, in itself a very good idea. All that Colonel Fosbery says about the difficulty of doing good shooting when the butt-plate is below its proper position on the shoulder is very much to the point; nor does there seem to be any serious practical difficulty in the use of such a sight if the thumb-screw arrangement on the upper band is replaced by a neat spring-clamp that cannot be easily knocked off, and a sheath for the sight provided in the butt-stock. To many of us the contemplation of the use of small-arm fire at 2000 yards and over is utterly absurd; but unfortunately for us, other people propose to so use it; and it would be very disagreeable to find ourselves being killed at those ranges while we were entirely unable to return the compliment in kind. The usual argument against long range firing is that no one hits anything, and that seamen never could; but the man who can make a fair target at 200 yards can hit an army or a camp at 2000, and the gun that can kill at 2000 has a longer danger space at 200 than a short range arm. To make our seamen, or part of them, fair long range shots and fair snap shots will of course require more training ashore than has heretofore been given; but this shore practice can be greatly and economically supplemented by use aboard ship of the Winchester tubes and fulminate 22 calibre cartridges in the service arms.

With these aids, even on a deck range of fifty feet, there can be instructive practice at great elevations (by finding the heights above the bull's-eye at which the small pellets will strike at the various elevations corresponding to sight graduations, and lining off the target accordingly) and at snap shooting at disappearing targets.

To the writer it is clear that if the Navy intends to be in condition to sometimes throw an infantry force on shore, the men must be equipped with a full powered magazine arm, fitted with a rear bolt-handle or other device that will enable them to deliver magazine fire from behind cover or from the shoulder without bringing the piece down between shots, with at least sixty rounds of

ammunition, an intrenching tool and sand-bags; they must be amenable to fire discipline, must know the capabilities of their arms and be able to bring them out at long and mid ranges and at snap shooting; they must be accustomed to moving in open formations and in successive lines; and must know how to quickly make and take cover. If these plain necessities for shore fighting cannot be met by the Navy, the idea of landing a force should be abandoned, and small-arm fire used only from aboard ship; in which case the arm should be of a large calibre smoothbore magazine type, devised to use multi-ball cartridges at ranges not exceeding 300 yards.

WM. W. KIMBALL, Lieut. U. S. N.

BIBLIOGRAPHIC NOTICES.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE, 1882.

PART X. Results of recent investigations on deep sea and ocean physics. The thunder storm of Aug. 9, 1881. Log notes. Entries in Meteorological Journal of the German Observatory for June, 1882. Remarks on the harbor of Porto Grande at the island of St. Vincent. Appendix to the sailing directions for the Tonkin Gulf. Greatest depths reached with sounding apparatus up to 1882. (The results obtained by Schley in the Essex, Sigsbee and Bartlett in the Blake, Belknap in the Tuscarora and Belknap in the Alaska are recorded in this table.) Comparison of the weather of North America and Central Europe for July, 1882. Brief hydrographic notices, tables and maps.

PART XI. Bartlett's researches in the Gulf Stream in the steamer Blake. The influence of a change in temperature upon the upper air currents and the transmission of the barometric minima. Comparison of the weather of North America and Central Europe for August, 1882. Entries in the Meteorological Journal of the German Observatory for July, 1882. Log notes, brief hydrographic notices, tables and maps.

PROCEEDINGS AMERICAN ASSOCIATION ADVANCEMENT OF SCIENCE. VOL. XXX, 21, 1881.

A Preliminary Investigation of the Two Causes of Lateral Deviation of Spherical Projectiles, based on the Kinetic Theory of Gases. Prof. H. T. Eddy, University of Cincinnati, Ohio.

The passage of a projectile increases the density of the atmosphere in front of it, but decreases that behind it. If the atmosphere had no viscosity and there was no friction, the increase of the density in front would be equal in amount to the decrease of the density in the rear; but viscosity and friction cause a current which increases in velocity and volume from front to rear, so that the decrease below the mean density is not so great in the rear of a projectile as the increase above the mean in front of it.

If now a spherical projectile have a velocity of rotation (about a vertical axis for example) as well as a horizontal velocity of translation, two causes of lateral deviation are developed: first, friction causes a deviation toward the side of the projectile possessing the greatest velocity; and secondly, the unequal distribution of pressure causes a deviation toward the side having the least velocity.

Friction exerts its greatest deviating effect at high velocities of translation, but the pressures, on the contrary, at low velocities. From this it may readily occur that the deviation of a projectile is in the first part of its path controlled by the frictional component; while in the latter part of its flight, after a

part of its initial velocity has been lost, the deviation is controlled by the pressures, thus causing a point of inflexion in the horizontal projection of its path.

Theory of the Flight of Elongated Projectiles. Prof. H. T. Eddy.

Professor Magnus is the inventor of a piece of apparatus intended to illustrate this phenomenon. He mounted a solid in the form of an elongated projectile after the manner of a gyroscope, so that it could rotate fully about two unequal principal axes of inertia. He then directed a current of air obliquely upon the shot while in rapid rotation about its axis of figure. This axis then suffered a continuous slow angular deviation due to the unequal pressures. The mathematical theories of the deviation of long shot from rifled guns have been based upon this phenomenon.

This note points out that the effect of friction, which may often be found to be the controlling factor in the deviating force, and which is entirely neglected in this experiment, exerts a deviating force coinciding in deviation with that of the pressures, and that the friction should therefore not be neglected in any complete discussion of such deviation.

Old and New Latitudes on the Atlantic Coast. Rev. Edmund F. Slafter, before N. E. Historic-Genealogical Society; being an inquiry into the history and causes of the incorrect latitudes as recorded in the journals of the early writers, navigators and explorers of America, with a discussion of the errors of the instruments used.

Marcus Baker, of Washington, publishes a paper on Alhazen's Problem in the American Journal of Mathematics. This problem was first solved in the eleventh century, and has since been considered by the most eminent mathematicians. Baker extends the problem first to the surface of a sphere and then to that of an ellipse. By the first he solves this problem. The great circle track between San Francisco and Yokohama reaches nearly to 52° N. The Pacific Mail avoid going north of 45°. Now if 45° be designated as the latitude north of which the steamer is not to go, in what longitude must this parallel be reached in order that the steamer's path shall be the shortest possible?

ENGINEER.

November 17. The Risks of Electric Lighting.

An editorial on the risks incurred by workmen, and danger to buildings from electric lighting; with suggestions as to the precautions to be used.

The Foundering of the Austral.

This case may be classed with the loss of the Royal George, to which it is similar in many respects. The Austral is one of the Orient Steam Navigation Company's line of steamers, a new vessel of 5500 tons. The facts in connection with the accident appear to be as follows: The vessel had discharged the whole of her cargo except 200 tons of iron, and was receiving her coal in the usual way on Friday, while lying in apparent security at her mooring in the harbor. The coaling was carried on through Friday night, indicating that the weather was calm and no unusual swell on the water. At 4 o'clock Saturday morning, when 1500 tons had been placed on board, the ship heeled over and sunk. The Austral was fitted with tanks along her bottom capable of containing 800 tons of water ballast, which was pumped in by steam power as the cargo was removed. It is stated that the water had been pumped out as the coaling proceeded, and it is suggested that the coal being untrimmed, and

the water ballast gone, the vessel would become topheavy, and any pressure on the side, arising either from wind or tide, would cause her to heel over, and allow the water to enter the coaling ports, and finally lead to her rolling over.

NOVEMBER 24. The Spezzia Armor Plate Experiments.

An interesting article on a series of experiments on plates designed for the barbette towers of the Italia and Lepanto. The trial of the plates was partly competitive, and three kinds of plates were tried, each 18.9 inches in thickness, furnished by three different firms; namely, Cammells, Brown, and the Schneider Creusot Company.

The Transmission of Power by Electricity.

A paper read before the Congress of Electricians, Paris, by M. Cabanellas, in which he flatly contradicts Sir William Thomson's statements on this subject.

DECEMBER 1. Conclusion of the experiments at Spezzia. An Apparatus for determining the Degree of Moisture in Steam.

The Ferranti Dynamo.

The advantages claimed for this machine are in simplicity and cheapness of construction and its small size and weight. These advantages have been secured entirely by the adoption of a very high velocity for the armature, making from 1900 to 2000 revolutions. To a great extent speed may be made to take the place of wire; that is to say, the electro-motive force of a dynamo may be augmented either by winding the armature or by increasing the speed, and Mr. Ferranti goes on the assumption that speed is cheaper than wire.

DECEMBER 8. St. Petersburgh Armor Plate Experiments.

A trial of armor plate recently made at St. Petersburgh, almost contemporaneously with the Spezzia experiments. The plates tested were Wilson's Compound steel-faced armor and Schneider's Creusot steel armor, each 12 inches thick and backed by 12 inches of timber. The gun used was an 11 inch Abookoff breech-loading gun, with chilled cast iron shells as projectiles.

Repairing Machinery at Sea.

The steamship Sandringham, on a voyage from London to the East, experienced a peculiar mishap. While under full speed the engines gave a loud crack as though something had burst, and then brought up. On taking off the low pressure cylinder cover, a large hole about three feet square was discovered on the side of the low pressure cylinder, the pieces of metal belonging to which were found on top of the piston. The weather being squally and a heavy sea on, the time for repairs was limited, so the idea suggested itself to the chief engineer to make a wooden patch, which he proceeded to do by fitting a piece of wood two inches thick by six inches broad between the jacket and cylinder face, bedding it close at both ends and holding it by means of countersunk screws through the cylinder face. Six pieces were put in and secured in this way, and then some hard wood was used to make the recess still remaining flush with the working face of the cylinder, the hard wood being screwed to the 6-inch pieces first mentioned. The cylinder cover was then put on and the engines tried with 45 lbs. steam pressure, and were allowed to work at half speed to the port of Syra.

The Strength of Boiler Flues.

A paper read by Mr. W. Martin before the Society of Engineers. The purpose of the author was to call prominent attention to the circumstance that little or no knowledge, derived from actual experiment, is in existence concerning the strength of boiler flues. In the words of the abstract of the paper, the only systematic series of experiments which have been made at all were

made by Sir William Fairbairn twenty-four years ago, and the formula deduced by him from these experiments is still the only one in use by engineers. The trustworthiness of this formula is not, however, beyond question; and its application to different cases can be made to produce somewhat anomalous results. It is much to be desired that the subject could receive a new experimental investigation, and in such a case the experiments should be with objects corresponding in shape and conditions of strain to actual flues.

Electric Lighting: an address delivered by Dr. C. W. Siemens before the Society of Arts.

DECEMBER 22. The Chemical Theory of Gunpowder: a lecture delivered before the Royal Society, by Professor Debus. Improved Machinery for Forging Anchors.

ENGINEERING.

NOVEMBER 10. Horizontal Engine with Lambert's Automatic Expansion Gear.

NOVEMBER 17. Gordon Dynamo-Electric Machine.

The object of the inventor was to produce a plant which would take, as it were, the place of large gas works for supplying light from a central station, and has proven quite successful.

The Babcock and Wilcox Boiler.

NOVEMBER 24. Boys' Power Meter.

The object of this engine power meter is to find automatically the amount of work done by steam or other fluid under pressure, such as gas, water, &c., upon the piston of an engine, and to record the result on a dial during any period of time, so that the total amount of work done in one or any number of strokes may be found by inspection and without calculation.

The Speed Trials of the S. S. Spartan.

An important paper read before the Institute of Naval Architects, in which are noted some valuable experimental facts connected with the speed trials of the Spartan, a large vessel built for the Union Company's Cape mail line.

The Weston System of Electric Lighting. Steam Engines and the Electric Light.

An editorial on the requirements of engines for driving electric light machinery.

DECEMBER 1. Thompson's Air Extractor.

The practical experience of the last few years has led most marine engineers to the conclusion that the presence of air in the water in a marine boiler is decidedly harmful. In marine engines the feed-pumps have a far larger capacity than is absolutely required, and under usual conditions of working they discharge into the boiler with the feed a certain quantity of air. In the apparatus under notice, the water is discharged from the feed-pump through a bell-mouthed pipe contained in a cylindrical vessel, provided near the bottom with a branch pipe leading to the boilers, and having at its top a piston air discharge valve, connected by a rod to a float contained in the cylindrical vessel. The air separating from the feed water on its discharge collects in the upper part of this vessel, and so long as the air valve is not closed by the rising of the float, escapes through the air valve. If, however, this escape takes place more rapidly than the air enters, the water level rises and the float is lifted, thus closing the valve. A glass gauge at the side shows how the vessel is working.

This apparatus was designed by the superintendent engineer of the Union Steamship Company, and has been found to answer the purpose well.

DECEMBER 8. Notes on the Manufacture of Solid Steel Castings: a paper read before the Iron and Steel Institute, at Vienna, by M. A. Pourcel.

DECEMBER 15. Surface Condensers.

A new formula for estimating the number of square feet of condensing surface necessary, by Cadet Engineer J. M. Whitham, U. S. Navy.

Ziese's Marine Boiler.

A marine boiler designed by Mr. Richard Ziese, and intended to avoid the direct action of the flame on the tubes and tube-sheet. The boiler is of the locomotive type, built of mild steel ½ inch in thickness; the furnace is contracted towards the top and contains a fire-bridge made of fire-clay, thus obviating the direct effect of the flame upon the tube-sheet.

INSTITUTION OF MECHANICAL ENGINEERS.

AUGUST. Single Lever Testing Machine.

A paper read at the summer meeting of the Institution at Leeds by Mr. Wicksteed on this subject was apparently most favorably received. The advantage of a single lever machine in rapid working is so great that nothing but a loss of accuracy could counteract it. Mr. Wicksteed holds the object to be tested in clips, the lower of which is connected to the piston of a hydraulic press, while the upper is connected to shackles, which are suspended from the main lever. The distance between the centres of the lever, each of which is a hardened steel knife-edge, is three inches. On the lever slides a movable ton weight, carefully adjusted with its centre of gravity in the centre line of the lever, and fitted on four small wheels to admit of easy motion. The movement of this weight over three inches will bring a pull of a ton on the sample, while a vernier scale admits of a strain of two and a quarter pounds being observed. The pull on the sample is made by the hydraulic press, which also takes up all extension, while the strain is counterbalanced and registered by the movable weight. Only two degrees oscillation are allowed the lever. It was stated that with this machine twelve specimens could be tested in an hour up to fifty tons.

Automatic Expansion Gear.

JOURNAL DE LA FLOTTE.

OCTOBER 29. Requirements for admission to the Naval School, 1883.

A decree of the Minister of the Marine, dated December 20, prescribes the methods for the examinations which are to be held on the first Monday in June, 1883, in all the principal cities of France.

The candidate is required to certify that he is French, and that he was not less than fourteen nor more than eighteen on the first of January, 1883. The examination is divided into two parts, called "compositions" and "examinations"; the former, consisting of writing from dictation, translation, drawing, etc., is held first, and only those who pass satisfactorily are afterwards admitted to the "examination" proper. The latter is oral, and is limited to one hour, no candidate having more than two examinations in one day.

The subject-matter of the examination is as follows:

French.—Fontaine's Fables, Télémaque, Voltaire, Charles XII, Montesquieu, Rise and Fall of the Romans.

Latin.—Cæsar and the first three books of Virgil.

English.—Irving's Columbus, abridged.

Mathematics.—Elementary mathematics.

Statics.—As far as simple machines.

Physics.—Elementary physics, gravitation and heat.

Chemistry.—As far as metals.

The compositions and times allowed for writing, are:

French composition.—Three hours.

Latin composition (with dictionary), and English (without dictionary).—Three hours.

Geometry and Statics.—Three hours.

Drawing, Descriptive Geometry and from model.—Three hours.

Arithmetic and Algebra.—Three hours.

Plane Trigonometry.—Three hours.

Physics and Chemistry.—Four hours.

Candidates will be marked on a scale of twenty, and the marks combined by multiplying each by a coefficient and taking the sum. The coefficients are as follows:

	Letters.			Sciences.	
	Compositions.	Examinations.		Compositions.	Examinations.
French,	4	6	Geometry,		8
Latin,	2	6	Statics,	6	4
English,	2	8	Arithmetic,		6
History,		4	Algebra,	6	7
Geography,		4	Plane Trigonometry,		4
Drawing,	4		Descriptive Geometry,	3	4
	—	—	Physics,		5
	12	28	Chemistry,	3	4
				—	—
				18	42

Total 100.

DECEMBER 3. Optical Signals between Mauritius and Réunion.

A few details are given of the proposed plan of optical telegraphing between these two islands. Two Mangin projectors of 60 cm. diameter are used, with petroleum lamps of peculiar construction in the foci. By eclipses of long or short duration the Morse code can be used, the signals being observed by telescopes. The attempt is to be made to register them by placing slips of paper sensitized by gelatino-bromide of silver in the focus of the receiving instrument. The station at Mauritius is at an altitude of 2460, and that at Réunion at 3700 feet. The intervening distance is 133½ miles.

JOURNAL OF THE FRANKLIN INSTITUTE.

DECEMBER. An improved dynamometer. The Isochronal Worthington Pumping Engine. Explosive and dangerous dusts. Economical steam power.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

NO. XI. Improvements in the Art of War during the last twenty years and their probable effect on future military operations. (Prize Essay, Lieut.-Col. Lazelle.) Electric telegraph in warfare.

REVISTA GENERAL DE MARINA.

OCTOBER. Elements of naval tactics. On naval service in the Philippines. Prevention of collisions at sea. On tactical trials of ships. Naval combats between 1860 and 1880. Notes on the Paris Electrical Exhibition.

NOVEMBER. Elements of naval tactics. On naval service among the Philippines. Naval combats between 1860 and 1880. Notes on the Paris Exhibition. On comets. On combined military and naval operations.

NOVEMBER. Reflections on naval tactics. The naval appropriations. On the formation of cyclones. Naval warfare and the military ports of France (trans.) Thornycroft torpedo-boats (trans.) Experiments at Meppen (trans.) Collisions at sea.

ROYAL UNITED SERVICE INSTITUTION.

No. 116. Magazine rifles (see Book Reviews). On the manœuvring powers of ships.

No. 117. On the future of electric lighting. On compass corrections in iron ships (see Professional Notes).

RÉUNION DES OFFICIERS.

OCTOBER 14. The Hebler gun (with table of trial tests appended.)

OCTOBER 21. Magazine Guns.

An examination into the arms in use in different countries, and accounts of different tests made; continued in subsequent numbers.

OCTOBER 28. The Military Applications of Electricity.

A synopsis of the more recent applications, treating of the field telegraph, of optical telegraphing by the aid of the electric light, of the use of the light itself and of the electric telemeter. A resumé is given of the use of the heliograph by the English in the Zulu and Afghan campaigns, by the Russians in Central Asia and Turkey, by the Spanish in the Carlist war, and by other nations in practice manœuvres, and the ease with which electric light apparatus could be used in this way in cloudy weather or at night is pointed out. The portable electric light apparatus in use in the French army is the Gramme dynamo machine and Mangin projector, the latter being of three sizes of 90 cm., 60 cm. and 40 cm. diameter. Of the first there are forty in service at fortified posts; of the second twelve for field use, and a number of the smallest size which can be readily transported by two men are also in service.

SCHOOL OF MINES QUARTERLY.

SEPTEMBER, 1882. On Nitroglycerine. On Nitrosaccharose.

Notes on River and Harbor Surveys. Improvement of the Wisconsin and Fox rivers. A new Compound Hoisting Engine. Inspection of Iron at Pittsburgh. Instructions for Disinfection, prepared for the National Board of Health by Professors Geo. F. Barker, Chandler, Draper, Remsen, and Drs. Janeway and Van der Poel.

Disinfection is the destruction of the poisons of infectious and contagious diseases. Deodorizers, or substances which destroy smells, are not necessarily disinfectants, and disinfectants do not necessarily have an odor. Disinfection cannot compensate for want of cleanliness or of ventilation.

I. DISINFECTANTS TO BE EMPLOYED. 1. Roll sulphur (brimstone) for fumigation; 2. Sulphate of iron (copperas) dissolved in water in the proportion of one and a half pounds to the gallon, for soil, sewers, etc.; 3. Sulphate of zinc and common salt, dissolved together in water in the proportion of four ounces of sulphate and two ounces salt to the gallon, for clothing, bed-linen, etc.

Note. Carbolic acid is not included in the above list for the following reasons: it is very difficult to determine the quality of the commercial article, and the purchaser can never be certain of securing it of proper strength; it is expensive when of good quality, and experience has shown that it must be

employed in comparatively large quantities to be of any use; it is liable, by its strong odor, to give a false sense of security.

II. HOW TO USE DISINFECTANTS. 1. *In the Sick-room.* The most available agents are fresh air and cleanliness. The clothing, towels, bed-linen, etc., should, on removal from the patient, and before they are taken from the room, be placed in a pail or tub of the zinc solution, boiling hot, if possible.

All discharges should either be received in vessels containing copperas solution, or, when this is impracticable, should be immediately covered with copperas solution. All vessels used about the patient should be cleansed with the same solution.

Unnecessary furniture, especially that which is stuffed, carpets and hangings, should, when possible, be removed from the room at the outset; otherwise they should remain for subsequent fumigation and treatment.

2. *Fumigation* with sulphur is the only practicable method for disinfecting the house. For this purpose, the rooms to be disinfected must be vacated. Heavy clothing, blankets, bedding and other articles which cannot be treated with zinc solution, should be opened and exposed during fumigation, as directed below. Close the rooms as tightly as possible, place the sulphur in iron pans, supported upon bricks placed in wash-tubs containing a little water; set it on fire by hot coals, or with the aid of a spoonful of alcohol, and allow the room to remain closed for twenty-four hours. For a room about ten feet square, at least two pounds of sulphur should be used; for larger rooms, proportionally increased quantities.

Cellars, yards, stables, gutters, privies, cesspools, water-closets, drains, sewers, etc., should be frequently and liberally treated with copperas solution. The copperas solution is easily prepared by hanging a basket containing about sixty pounds of copperas in a barrel of water.

4. *Body and Bed-clothing, etc.* It is *best* to burn all articles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows:

(*a*) Cotton, linen, flannels, blankets, etc., should be treated with the boiling-hot zinc solution; introduce piece by piece, secure thorough wetting and boil for at least half an hour.

(*b*) Heavy woollen clothing, silks, furs, stuffed bed-covers, beds and other articles which cannot be treated with the zinc solution, should be hung in the room during fumigation, their surfaces thoroughly exposed, and pockets turned inside out. Afterward they should be hung in the open air, beaten and shaken. Pillows, beds, stuffed mattresses, upholstered furniture, etc., should be cut open, the contents spread out and thoroughly fumigated. Carpets are best fumigated on the floor, but should afterward be removed to the open air and thoroughly beaten.

5. *Corpses* should be thoroughly washed with a zinc solution of double strength; should then be wrapped in a sheet wet with the zinc solution, and buried at once. Metallic, metal-lined, or air-tight coffins should be used when possible; certainly when the body is to be transported for any considerable distance.

MÉMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

AUGUST, 1882. Note on the Purification of Feed Water for Boilers.

The writer recommends the use of magnesium oxide, since it precipitates the lime salts as insoluble carbonates. When calcium sulphate is present, the magnesium carbonate reacts with it, forming calcium carbonate and magnesium sulphate. The latter is very soluble. This latter reaction presupposes the existence of carbon dioxide or of acid carbonates in the water.

On the Lodging of Troops in Barracks. Notice of the work of the Congress of Hygiene at Geneva, Sept., 1882. Ballistic experiments

on the Resistance of the Air in Guns. Compound Engines without Condensation. Economy of Steam Engines. Sonorous and Luminous Buoys.

SEPTEMBER. Studies in Oyster Culture. The Coal of Turkey in Asia. Heating Locomotives with Petroleum. Towage on the Spree. Destruction of a Wreck by Dynamite. On the action of Zinc Plates in Boilers and a Process for Avoiding Explosions.

The zinc and iron form an electro-chemical couple which decomposes the water, the oxygen going to the zinc and protecting the iron. The zinc oxide formed unites with the fat acids present, forming zinc soaps which prevent the scale from adhering. The hydrogen liberated moderates the ebullition of the water, and thus prevents superheating and consequent explosion. As the liberation of the hydrogen does not go on regularly, however, the author proposes adding carbon dioxide to the water to ensure a constant and regular liberation of the hydrogen.

The Dynamometric Balance of M. Raffard. Note on Amsler's Planimeter. Purification of Cast Iron and Steel by Moist Hydrogen.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

NO. X, 1882.—Naval events in Italy during the revolutionary conflict of 1848. Discussion of firing trials at Krupp's works. E. Bourdon's multiplication anemometer. Relative rank of officers of the Austrian, German, Italian, French, English and United States Navies, arranged on the basis of the army rank. Experiments with boiler tube expanders for torpedo boats. Upon submarine mines. Steel stern-post knee and rudder. Experiments regarding the Chatham gas explosion. Pintsch's system for lighting buoys by gas. Submarine mine finder. Notes on the English and French navies. The Brazilian ironclad Riachuelo. Launching of the German dispatch boat Pfeil. German fortifications on the Baltic. The Australian expedition to Jan Mayen's Land. Mr. Leigh Smith's two voyages to Franz Josef's Land.

MITTHEILUNGEN U. GEGENSTÄNDE D. ARTILLERIE U. GENIE-WESENS.

PART VII. 1882. Experiments to test the value of dynamite in driving piles. Firing trials of coast artillery and breech-loading guns in Italy. Trial of a 9 cm. steel bronze gun at Seville. Weldon's prism telemeter. Data for the Swedish 27 cm. cannon and the Danish 15 cm. howitzer. Practical rules for firing with small charges. Introduction of a new revolver in Switzerland. Spanish percussion primers M. 1882. Arming of the Portuguese coast battery Bono Sucesso with 28 cm. steel cannon. Cast-steel guns in Russia. Firing trials at Carabanchel. Temperature of the glass globes of incandescent electric lamps. The fibre distance measurer. Use of phosphor bronze wire for telephones. Palliser's friction primer.

PARTS VIII AND IX. Notice of the electro-technical exhibition in Paris. Firing trials at Krupp's works. Russel & Livermore's magazine gun. Testing a compound armor plate with the 10-ton Armstrong gun. Trial of a new

repeating rifle in France. Data on the new Spanish 8 cm. experimental gun of steel. Trial of armor in Russia. Estimate of work in the ordnance shops and factories of Spain for 1882.

PART X. Notice of the electro-technical exhibition in Paris. Manganese bronze. Absolute measure of the strength of the electric current. The secondary battery of Sellon & Volkmarr. Kabath's accumulator (secondary battery). Tachometer and Tachograph.

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Traité theorique et pratique de la Regulation et de la Compensation des Compas. Par A. Collet, Lieutenant de Vaisseau.